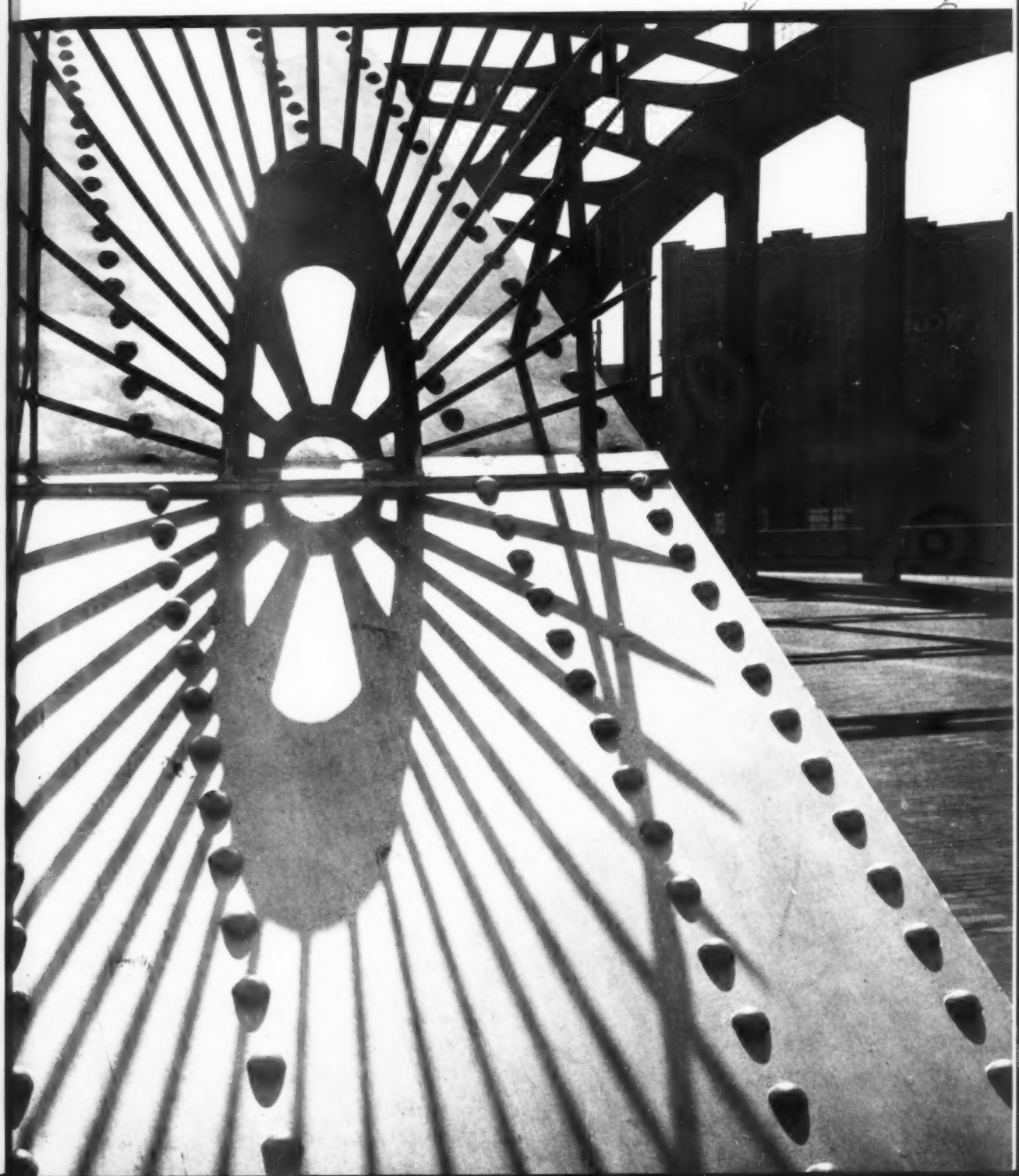
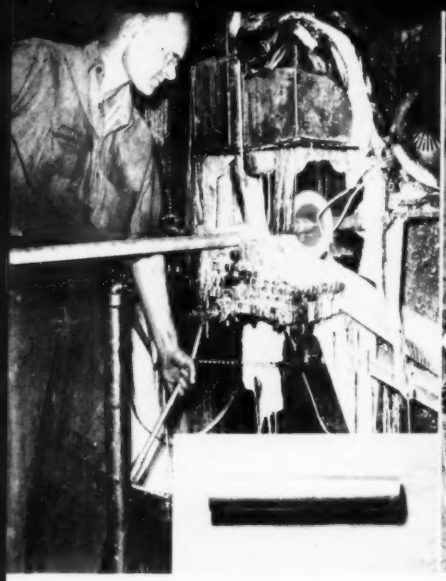
TECHNOLOGY DEPARTMENT

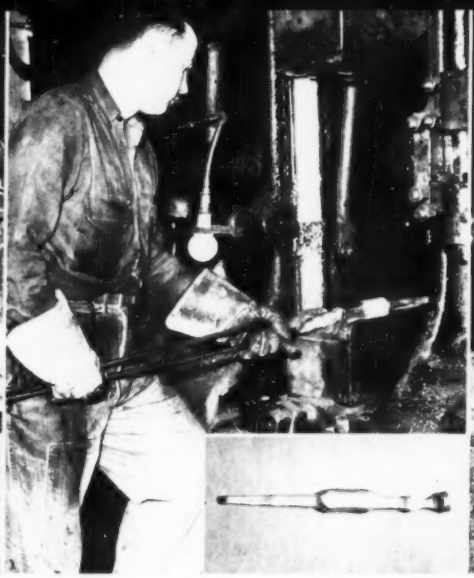
TECHNOLOGY REVIEW

December 1948





Cutting Bar



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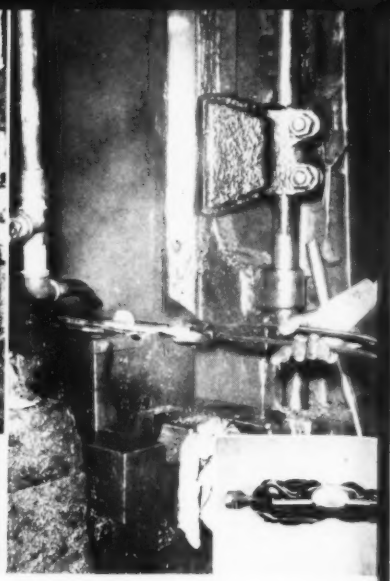
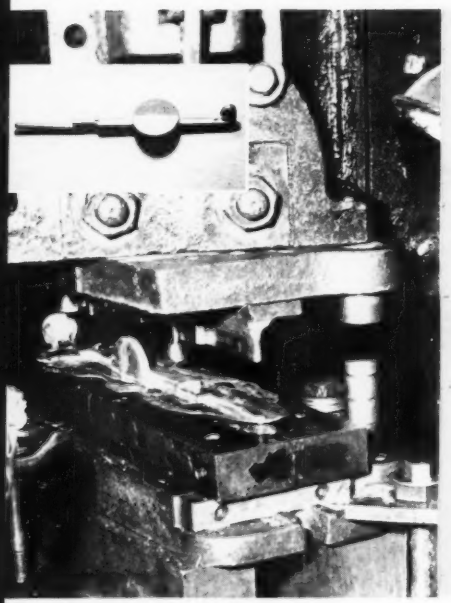


Shaping to the Die



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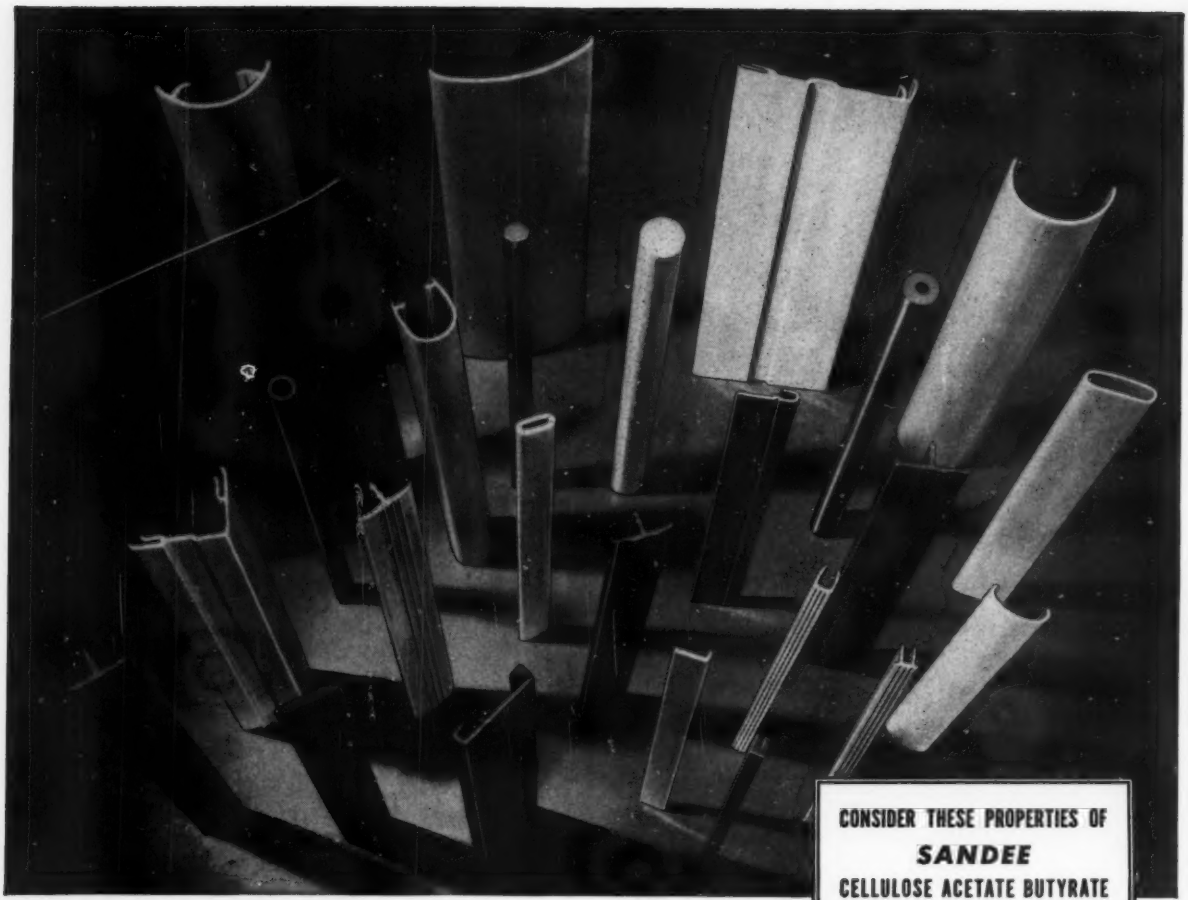

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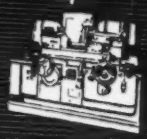

GRINDING MACHINES

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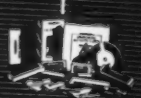

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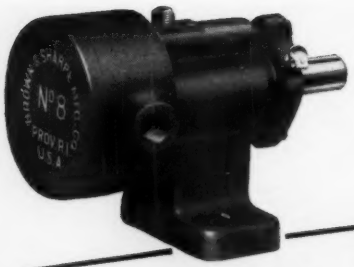

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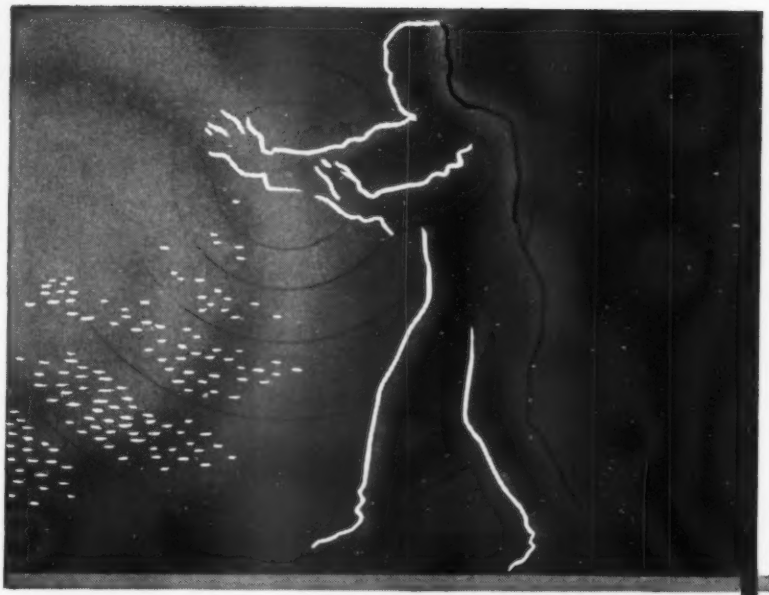
THE TABULAR VIEW

Tomorrow's Living. — PROFESSOR THOMAS K. SHERWOOD, '24, Dean of Engineering, is an able expositor (page 98) of his belief that both barrels of our educational shotgun should be fired together; one barrel to instill in the general citizenry an understanding of the true meaning, significance, and methods of science, and the other barrel to broaden the training of scientists and engineers through a better understanding of economics, history, social sciences, and the many other topics which can be conveniently lumped together as the humanities. In this way he envisions a more intelligent approach to tomorrow's living. Dean Sherwood is scientist turned educational administrator. He received the bachelor of science degree from McGill University in 1923, and from M.I.T. the S.M. and Sc.D. degrees in 1924 and 1929, respectively. During World War II he was a member of the National Defense Research Committee, a consultant on the Baruch Committee and to the War Department.

Today's Progress. — TENNEY L. DAVIS, '13, turns up evidence (page 101) that Chinese warriors of centuries ago were formidable foes, having developed rocket-arrows for military purposes certainly as early as the Seventeenth Century and possibly as early as the Thirteenth. The documentary evidence which Dr. Davis has unearthed in his research for this article gives ample evidence that today's progress depends on past accomplishments. As an authority on modern explosives, an able historian for chemistry, and a frequent contributor to learned journals, Dr. Davis is well qualified to prepare this article for The Review. At Harvard he received an A.M. degree in 1915 and a Ph.D. degree in 1917. He was a member of the Institute's Faculty from 1919 until his resignation in June, 1942. He is director of scientific research and development of National Fireworks, Inc.

Yesterday's Tribute. — In spite of the doctrines of dictators, to the contrary, science knows no nationality; although the barriers of language may temporarily hold men of science apart, their professions bring them together. No better example could be cited than the tribute which a German scientist paid to a modest French professor of mathematics somewhat more than half a century ago when feelings of nationalism were probably at their height. DAVID and CHARLOTTE B. LANDAU record (page 103) the warm, personal life of André-Marie Ampère, and the part which Helmholtz played in immortalizing the French savant. In New York, David Landau follows his vocation as engineer, specializing in stress studies and elastic theory, whereas Charlotte B. Landau, a graduate in science from French schools, is a teacher and writer on science and scientists.

Enzyme Kinetics. — SAMUEL A. GOLDBLITH, '40, whose Trend piece appears on page 97, is a graduate student in the Department of Food Technology where he is studying for an advanced degree.



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I notice on page 40 of your November, 1948, number that Henry Richards of the Class of 1871 has celebrated his 100th birthday. If I correctly understand it, he is the brother of the late Robert H. Richards of the Class of 1868 who also lived to pass his 100th birthday. I do not recall any other authenticated case in history of two members of one family reaching and passing the age of 100 years.

Boston, Mass.

Music and Mechanism

FROM HERBERT V. WHITE:

Last summer a friend gave me a copy of the June, 1948, issue of The Review. His primary purpose in doing so was that I might see the photograph on the front cover. Due to the fact that I am an organist, this photo was of much interest to me. However, I am unable to identify the organ pictured. Would you kindly send me, at your earliest convenience, any information which you might be able to obtain on the instrument.

Hartford, Conn.

[*As we informed Mr. White and the many other inquirers about this photograph, the organ console pictured is located at Wanamaker's store in Philadelphia. – Ed.*]

Bouquets for Volume 50

FROM CARL T. KELLER:

I hate to inflate your ego any further, but in justice to the men who really do the work, I state that the last [July] number of The Review was not only the best, to my mind, of all the many issues of that excellent magazine which I have read, but the best of any such publications which I have ever seen. Even Mrs. Keller read parts of it with interest and I devoured it from "kiver to kiver"! I am keeping it amongst my treasures. My congratulations and keep it up!

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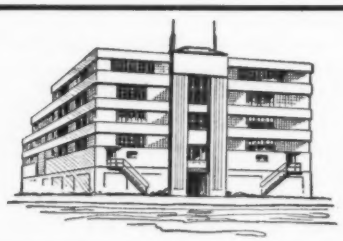

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THE TECHNOLOGY REVIEW

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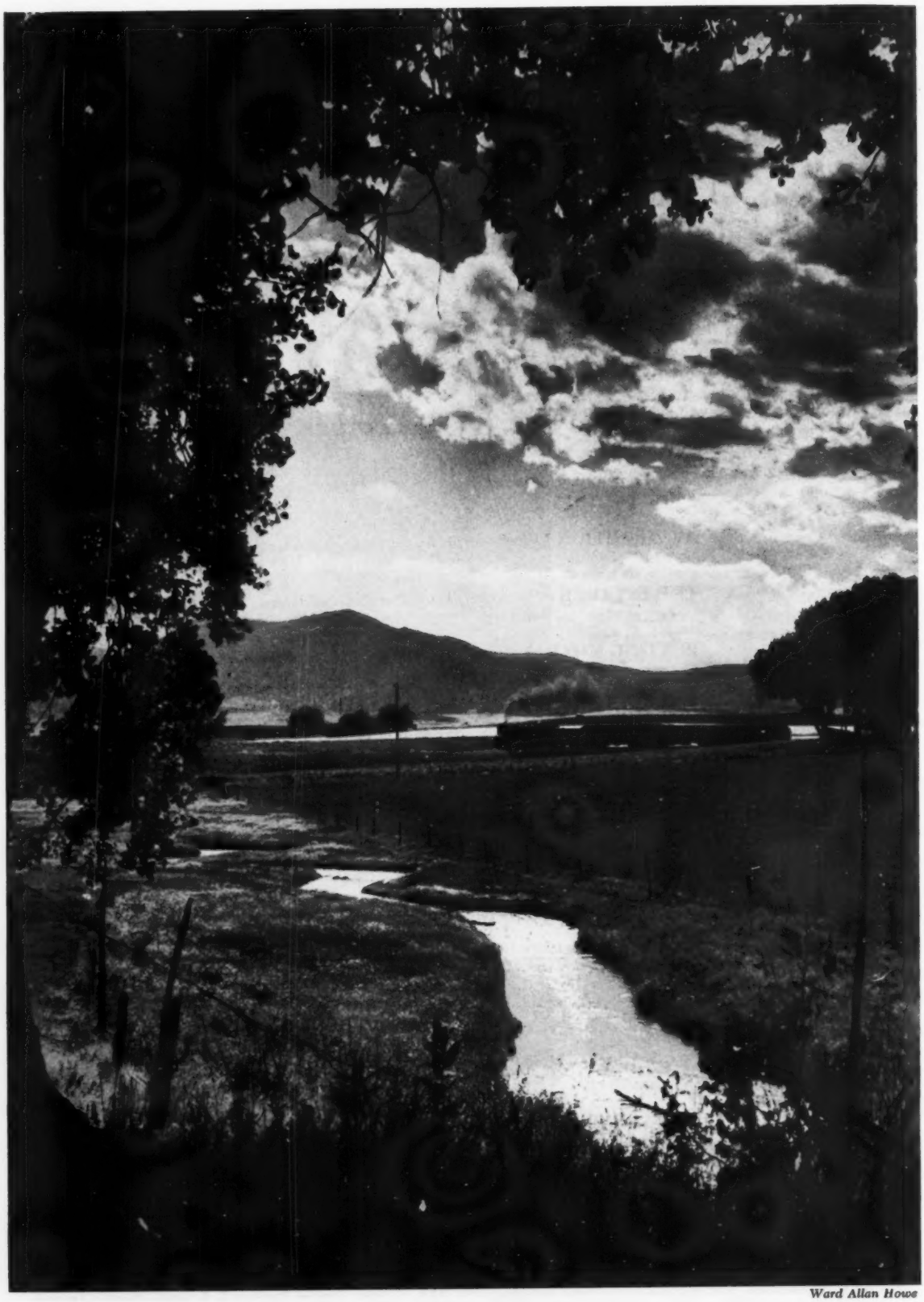


Ward Allan Howe

The Invader

THE
TECHNOLOGY
REVIEW

Vol. 51, No. 2

December, 1948

The Trend of Affairs

Bountiful Bossy

THERE are now one fifth as many dairy cows as persons in the United States. And by diverting Bossy's milk secretion from its original purpose of nurturing her calf, man has gained not only an important element of his food supply,* but also an extensive array of valuable nonfood products.

One serious difficulty in the economy of the cow has been the problem of by-products. Even calves may be by-products, for often the main purpose of calving is to freshen the cow's flow of milk. Furthermore, only half of the milk produced in this country is consumed as such; the remainder is used to make cream, butter, or cheese. Separation of cream leaves skim milk as a by-product; butter production leaves buttermilk; and cheese manufacture leaves whey. But in each process the by-product amounts to well over 90 per cent by weight of the original milk.

Originally skim milk, buttermilk, and whey were either discarded or returned to farms for feeding to livestock. Later some skim milk, particularly in concentrated or dried form, found its way into the food-manufacturing industries. Nevertheless, these milk by-products, until recently, represented a serious economic loss, as well as a waste of potentially valuable materials. Now, however, such waste has been virtually eliminated by successful application of the chemurgic approach, leading to separation of the by-products into various fractions, for use as such, for modification, or for use as ingredients in the making of numerous valuable products, some of them extraordinarily remote from the original food nature of milk.

The first constituent of milk to find industrial application was casein. Casein is a protein that constitutes some three per cent of whole milk; it is separated from by-product, skim milk, by coagulation, either with acid or with the enzyme, rennet. The original use for casein, and still the largest one, is in coating paper. Casein is also used in adhesives, paints, plastics, rubber, and building materials. Recently, casein fibers have been perfected for use in textiles; these fibers can be made with properties simulating those of the relatively expensive fur and wool. Likewise paintbrush bristles, now made from casein, are said to rival the costly natural hog bristles normally used. Digests of casein, and also of lactalbumin, a secondary milk protein, are used as flavoring materials in food manufacture, for pharmaceutical applications in amino-acid therapy, and also as ingredients in bacteriological media where they supply nutrients for micro-organisms. Calcium or sodium salts of casein are used in infant feeding.

Another milk constituent that falls into the by-product category is the sugar, lactose. Lactose, it is of interest to note, is the only commercially important sugar of animal origin. It is also the largest single component of the solids of milk, as it constitutes approximately five per cent by weight of the average milk. Lactose remains in the whey resulting from cheese manufacture, so that this material, as well as the by-product, skim milk, is a commercial source of the sugar. The uses of lactose are many and varied. Certain of its properties make it uniquely valuable as an excipient and coating in pharmaceutical manufacture. It is frequently used in infant foods. Some processes for penicillin production rely upon lactose as an essential ingredient of the substrate. Lactose also is the raw material for a fermentation process that yields lactic acid, a material widely used in industry.

In addition to the utilization of whey by separating out of lactalbumin and lactose, considerable whey is now used unaltered as the substrate for another industrial fermentation that yields a good vinegar.

As a result of the developments described, little skim milk, whey, or buttermilk need be discarded today. The average cow produces some two tons of milk annually, and now that virtually all, rather than approximately half, of this bountiful flow is being put to useful purposes, Bossy has become still further entrenched as a valuable citizen.

* The Technology Review, May, 1947, page 403.

Photo by Harold E. Edgerton, '27

Studies of the metabolism of the bat require an unusual grasp of thermodynamics, as well as of biology, for the body temperature of these flying creatures in flight (about 104 degrees F.) is considerably greater than that at rest.

Internal Environment

IN one of his more celebrated essays, *circa* 1928, "On Being the Right Size," J. B. S. Haldane recounted some of the problems that plague the very large and the very small animals. The immutable laws of geometry ordain that, as long as mammals keep more or less the same shape, the ratio of surface to total weight must go up as their size goes down. It takes about 5,000 mice to weigh as much as one man, but between them the rodents have about 17 times as much skin area. Since they lose about 17 times as much heat as man (the body temperature of mice and men is much the same) the rodents require 17 times as much oxygen to burn the much greater quantities of food they need. In fact, a mouse must consume about one-fourth its weight in food every day.

Shrews, rather than mice, have received the most publicity for their voracious appetites, and they do indeed have record-breaking metabolic rates for mammals, but all small warm-blooded animals are heavy feeders. Their extreme characteristics in this respect have made them of interest to biologists and biochemists, for metabolism and body temperatures are key expressions of body processes. Research in this field is continuous, and although the published papers taken individually may seem as irrelevant as a fragment from a jigsaw puzzle, they fit into a coherent, although intricate, picture. The pages of *Science* during the past year provide the source of information for the following comments.

The minimum size for an adult mammal, says one worker, is 2.5 grams, or about one-tenth of an ounce. That figure was obtained by extending a curve of oxygen consumption per unit of body weight for various species of shrews. As the shrews grew smaller, their unit oxygen intake increased so rapidly that, it was concluded, a shrew weighing a tenth of an ounce would be unable to eat food fast enough to keep living. The young of many small animals weigh less than this minimum, but they escape the paradox of an infinite appetite by keeping their body temperature and their biochemical processes at less than adult levels. The nakedness and sparse feathering of many of these tiny infants may be an evolutionary adaption toward that end.

The bat is also a very small mammal, but has a peculiarity that prevents the scientists from putting a point for him down on the curve. Metabolically speaking, his is a split personality. At rest he has a relatively low body temperature, but when he wants to fly he works himself up to a temperature of 104 or 105 degrees F. (the level for birds) and generates energy at a rate necessary for a flying animal. To maintain that rate while he roosts would greatly increase the bat's food-gathering task, perhaps beyond his capabilities, and so he slips into low gear as a thrift measure.

The bat's behavior has a superficial parallel to that of the cold-blooded land animals, except that the bat can change his level of activity at will, while the poikilotherms, as the biochemists insist on referring to them, are slaves of the daily temperature variations. For fishes in the open sea, there is practically no temperature problem, for the thermal inertia of the tremendous mass of water in which they are immersed protects them from sudden fluctuations. Although a great evolutionary step was required to enable the reptiles and Amphibia to endure temperatures from near freezing to more then 100 degrees F., an existence independent from temperature did not follow. For activities that demand the rapid expenditure of energy, such as food gathering, active defense, or the sexual functions, the cold-blooded animals must wait, in effect, for a sunny day. Nor are they freed from making

Photo by Henry B. Kane, '24

Because the ratio of skin area to weight in mice is about 17 times that of man, rodents, such as this white-footed mouse, must consume one-fourth of their weight in food each day. The world's population would probably have become static long ago were man required to consume 40 or 50 pounds of food each day to maintain himself.

complex internal changes, for biochemical relationships in a dormant animal are far different from those taking place in animals whose body temperature is that of active mammals.

A few years ago it was shown that the blood pressure varies with the temperature in cold-blooded animals. More recently, the same effect has been shown to exist in warm-blooded animals once the mechanism that controls temperature is overcome. Still more significant is the discovery that warming or cooling of a tiny area in the brain, called the hypothalamus, creates the same effects as warming or cooling the entire animal. The hypothalamus has already been isolated as the control center for a wide group of apparently unrelated functions, such as the metabolism of sugars and fats, and the regulation of the sexual cycle, appetite, and respiration.

The suggested explanation is that "these functions may be considered as parts of an integrative mechanism" that adjusts the internal environment to the existing temperature. Perhaps it was the invention of the hypothalamus that permitted life to walk out of the sea and extend its domain over the land and air.

Putting Mother Nature to Work

By Samuel A. Goldblith

In considering the utilization of natural forces for power we commonly think of gas, coal, oil, water, electricity, solar energy, and so on. There are minute organic compounds – enzymes – found in all living materials which, serving as organic catalysts, are responsible for many chemical changes which occur in nature. In a sense, these enzymes might also be included in any list of natural sources of energy.

Enzymes are used now in numerous industrial processes. Their commercial use has increased rapidly since 1926 when James B. Sumner first successfully crystallized a pure enzyme, urease. Long before man knew of and had named enzymes, he was making use of them however. The conversion of cider into vinegar (where the enzymes of a group of bacteria, known as the acetobacter, convert the sugar of the cider into acetic acid) is a typical example of an early use of enzymes which survives to the present. The production of alcohol, wherein the enzymes of yeast are used to convert molasses sugar into ethyl alcohol, is another use which man has made of enzymes for countless ages. Beer has been brewed by man long before he knew that this common beverage was the result of the fermentation of starches by the enzymes of yeasts. Moreover, the sprouting of barley results in malt, which is rich in diastatic enzymes, and these break down the starches to simpler sugars in order that the yeast enzymes may convert the sugars to alcohol. Thus the characteristic flavor and stimulation of beer and ale are end results of the action of organic catalysts.

In 1878 Wilhelm Kühne proposed the word "enzyme" meaning "in yeast." It was Louis Pasteur who showed that the fermentations which occur in natural materials are due to the presence of micro-organisms in the fermenting materials. Edward Buchner, in 1897, showed that it was not necessarily the yeasts which fermented materials but rather the enzymes in the yeasts.

To date all of the enzymes which have been crystallized have been shown to be proteins of high molecular weight. Since Sumner's work, some 30 enzymes have been crystallized and studied in minute detail. Although not crystallized as yet a greater number still have been discovered and studied in detail. As a result of recent research, enzymes have been used commercially with much better success than previously. As a result the brewing industry, as well as a number of similar industries, has transformed the art of brewing into a science. Moreover, new improvements in processes result in better products produced at lower costs. This has been made possible as a result of research leading to a more complete knowledge of the chemistry and kinetics of enzymes.

Enzymes are destroyed by heat but are not inactivated by cold; they are less active at freezing temperatures however. Thus, in preparing edibles for preservation by freezing, it is of importance to inactivate the enzymes by a preliminary heating, known as blanching, in order to prevent off-flavor and deterioration of foods. Quantitative measurements of the rates of activity of enzymes at lower temperatures, by Irwin W. Sizer, Associate Professor of Physiology at the Institute, and Edward S. Josephson, '40, have given us a better insight into the necessity of blanching and the methods of determining the proper times and temperatures for proper blanching.

Enzymes are responsible for the proper digestion of foods in man and all animals where they function not only in the digestive tract, but also in the entire body. Man has even found a way to improve his own digestion through the production of enzymes in other animals. Thus, for example, the production of the enzyme, pepsin, from hogs' stomachs has become an important operation in the meat-packing industry. The pepsin thus produced is used medicinally by persons whose stomachs cannot break down proteins into smaller compounds which may become available to the body as building materials. A number of vitamins are a part of the enzyme system of the body which are indispensable for respiration and transport of oxygen.

The number of molecules of substrate which are decomposed per minute by one molecule of enzyme is called the "turnover number" and is a measure of the effectiveness of an enzyme. Catalase, the enzyme which decomposes hydrogen peroxide, has a turnover number of 5,000,000. Thus we see that enzymes can indeed be powerful catalysts, and that only a small amount of enzyme may be required to affect a molecular breakdown of sizable proportions.

The production of nearly all industrial alcohols and many organic compounds is due to the action of the enzymes of micro-organisms. Butyl, ethyl, isopropyl alcohols, acetone, lactic acid, glycerol, and so on are examples of this. The production of pickles, sauerkraut, and fermented milk products is due to the enzymes of the lactic acid bacteria. Cheddar cheese is another example of the action of an enzyme (rennet), obtained by extraction from the fourth stomach of the cow.

Thus we may see that enzymes, the biological catalysts present in all living materials, are of utmost importance to man's economy, and daily research on these is showing more uses.

Science in Education

Our Educational System Needs to —
Broaden Engineers and Scientists in the Humanities,
Provide a Better Understanding of the Real Meaning of Science

By **THOMAS K. SHERWOOD**

In a little more than a year we shall have passed the halfway mark in the Twentieth Century, ending what may prove to be quite the most remarkable and possibly the most significant half century in history. For in my lifetime mankind's accomplishments and general behavior have been paradoxical in the extreme – we have both reached the heights and plumbed the depths. Two wars have caused the death of nearly as many people as there are in the United States today; for this the Grim Reaper's total is at least twice as great as it was for all the war deaths during the preceding 1900 years of the Christian Era. Yet during this same half century, we, in this country, have enjoyed a higher standard of living than the world had previously known. In this same period we have expanded our educational system to the point that there are ten times as many students in college as in 1900, and four times as many students in college as in secondary schools 50 years ago. Outside of schools, education in music and the arts has become common; good music is known and enjoyed by millions of our people. The advances in medicine have done more to relieve our suffering and promote our physical well-being than all that was accomplished in the field of medicine in the previous 20 centuries.

That science has had something to do with the paradox of this half century is evident; science is responsible for both the atom bomb and for penicillin. The importance of science in our daily life and its implications for our future are evidenced by the current interest in all things scientific or technological. There are more students studying engineering today than were enrolled in all colleges in 1900. New magazines of popular science are started almost every month, or so it seems. News weeklies describe the doings of the scientists along with the news from Hollywood, reporting blow by blow the encounters of the research worker with nature's mysteries, telling us what a new synchrotron or telescope will accomplish even before the equipment is completed. Congressional debates on atomic energy or the establishment of a National Science Foundation assume the stature of major political issues. It is significant that such activity reflects much more than merely popular interest in household scientific gadgets – there is a widespread realization that science may have a great deal to do with how we live with each other as well as with the manner in which we live. The atom bomb did more than destroy Hiroshima and Nagasaki: It persuaded us, as nothing else had done, that science is of very great and of very real importance to everyone.

The remarkable developments of science and technology have been enumerated by many writers. What I should like to do is to emphasize the rapidity with which these developments have occurred in this last half century. This is most evident by a survey of the increase in our industrial productivity since Michael Faraday's experiments a hundred years ago laid the foundation of our great electrical industry. In 1944 the net output of the economy of this country was 27 times larger than in 1850 and was turned out by a labor force only nine times larger, working 43 instead of 70 hours each week. In terms of 1944 prices, the net output of all goods and services in 1944 was $161,000,000,000 as against $6,000,000,000 in 1850. The increase raised the average income of Americans from about $270 in 1850 to about $1170 in 1944. Technology is largely responsible for these changes.

The great developments of the automobile and aircraft industry are familiar to everyone. About the time I was born the Wright brothers made their famous first flight at Kitty Hawk. Four years ago the modern version of the Wright machine brought two great nations to their knees. A lesser example of the advance of technology is the improvement in the automobile tire. In 1907 an average workman's wage for one hour was sufficient to purchase 20 miles of tire life; today an average hour's earnings will purchase a tire mileage of 2,120. Technologically, Russia today is about where we were shortly after the turn of the century. A Russian workman must work 320 hours to purchase a cotton shirt; in this country the shirt can be purchased with the average wages for three hours' work. The Russian must work 1,600 hours for a wrist watch; the American, 30 hours. If any Russian felt he needed one, he would work four hours for a toothbrush; the American, 15 minutes.

More important than the development of automobiles, airplanes, and radio sets is the tremendous improvement in our general health and physical well-being. This change is evidenced by the fact that we live very much longer than our forefathers. From studies of the character of fossil remains it is estimated that the average life span of prehistoric man was about 18 years. At the time of the Roman Empire the average lifetime had increased to 22 years, and in the Middle Ages it was about 32 years, which is approximately the figure for India today. When I was born my life expectancy was 49 years, on the basis of which I am not long for this world. Today the life expectancy at birth in the United States is 66 years. More years have been added to man's lifetime since I was born than

during the preceding one thousand years. These changes have been the result of better living environment, better nutrition, and of the advances resulting from the application of science to medicine.

Perhaps the rapidity of the change in our environment is best summarized by quoting from one of my colleagues: "In my own lifetime has occurred the development of every single thing which distinguishes a high from a low standard of living. When I was born the telephone had been invented but was not in use. Electric power, the internal combustion engine, x-rays, moving pictures, the airplane, radio; even central heating, good roads, and a continuous supply of fresh food have all come since I was born. The world into which I was born was more like that of Julius Caesar than like that of the present day." The man who recently said that is 67 years old.

Rapid change often produces stresses, and usually presents new and troublesome problems. Certainly it is important to know whether the change is in the right or wrong direction, but the perspective necessary to evaluate the trend is difficult in a period of rapidly changing conditions. A person's weight may be expected to change gradually over a period of years; a gain or loss of 15 pounds in a few weeks is a danger signal to the physician. A train traveling at high speed around a curve is more difficult to keep on the track. Skiers on a downhill course know well that they must be most keenly alert on the steep pitches. There is little time to size up the bumps in the trail and the branches protruding through the snow. The wind causes their eyes to water, and it is difficult to see ahead. The steep pitches are the most dangerous and difficult parts of the trail, but they are also the most stimulating and exciting. It is for these experiences that people go skiing. We live in a high-speed age, but the rapidity with which our whole way of life is changing is more exciting and more significant than the rate at which our automobiles and airplanes are increasing our speed of locomotion.

What Kind of Higher Education?

The broad picture of rapid change which I have attempted to paint seems to me to have implications of special significance to the field of education. The President's Commission on Higher Education recently suggested the need of college education for a much larger fraction of our young people than are now in colleges, and recommends a program of Federal aid to the end that present college enrollments would be doubled by 1960.

What kind of higher education should the colleges offer? The economic implications alone suggest the need for a most careful scrutiny of the job we are doing in the colleges. Has the character of college education kept up with the needs of this period of rapid change? Can we predict what kind of educational background the middle-aged leaders of the 1970's will need in order that we may make provision for it in our colleges today?

A typical college course of 100 years ago contained approximately six years of Latin and Greek; mathematics through the calculus; surveying and navigation; at least one year each of physics and chemistry; astronomy; a year course each in rhetoric, moral philosophy, political economy, and history. This does not sound greatly different from the liberal arts program of today as elected by most of the students in colleges. The principal difference is that most students today study less science and mathematics than did the college student of 1850. In the face of a revolutionary change in our whole way of living (a change due very largely to science and technology) liberal arts programs today appear to provide graduates with no better basis for understanding science and technology than did the colleges in the nonscientific period of a century ago. It is this aspect of present-day higher education which concerns educators and which, undoubtedly, should be corrected.

Changing the Curriculum

Scientists and engineers represent a very small fraction of our population, and perhaps too much has been assumed as to their ability to understand and be responsible for the implications and applications of what they do. The Brazilian delegate to the United Nations, Oswaldó Aranha, has said: "The people that disintegrated the atom now have the mission of integrating humanity." But we must not assume that the "people" who will do this are Doctors Oppenheimer, Urey, Fermi, Compton, Seaborg, and the rest of the small group who get the credit – and the blame – for the atom bomb. Those who must do this are all of us, most of whom are graduates of liberal arts colleges. It seems extremely important that these people know more about science and technology if they are to shoulder their great responsibilities as citizens.

Tinkering with the curriculum is the favorite indoor sport of educators, especially of college faculties and college administrators. In recent years the pendulum has been swinging back from the free elective system, and the tinkering has frequently resulted in the requirement of a series of subjects to be taken by all undergraduates in the college. The object is to provide a general education by insistence on a "common core" and the new curricula are not unlike those described as common in 1850. One of the difficulties in providing this common core of required subjects is that the elementary courses in such branches of learning as economics, mathematics, or chemistry are designed as the first of a sequence of subjects for students majoring in the field, and are not planned for the many students who want to know about the subject but who do not wish to specialize in it. As a basis for further work in chemistry, the freshman course in chemistry is usually excellent, but is not particularly helpful to the future banker or farmer who should know something of the nature of science and of the way chemists think. To overcome this difficulty, Harvard, Colgate, and a number of other universities have instituted new subjects in general science, designed to stress the way in which science progresses, to show how scientists work and reason, and to indicate something of the possibilities and limitations of science in relation to the problems of nonscientists. This is an excellent idea, and this type of subject should grow in importance in the educational scheme, provided the pitfalls of the Cook's-Tour type of survey course can be avoided.

Science in Our Daily Life

Just why is it important for nonscientists and nonengineers to know more about science and technology? It is important because nontechnical persons have the responsibilities of citizens, and science and technology are important influences on their daily life. A few illustrations will make this point clearer.

The whole public discussion of atomic energy has been distorted by the failure of our people to appreciate the technology of bombmaking. From the newspaper accounts one would get the idea that the secret of the atom bomb might be written on a piece of paper, like a chemical formula, and sold to a foreign spy. Those who know a little about technology will tell you that it would be nearer the truth to say that there is no secret; that Russia's job of making an atom bomb is more nearly comparable to the difficulty the Chinese would have in setting up a plant to make 3,000 Fords a day. The difficulty is not so much with a few processes or reactions, which have been kept confidential, as it is with the complexity and size of the undertaking.

There has been a great deal of talk about atomic power plants, and there is even some disappointment that they are not yet in operation. Those who have a general knowledge of power production will tell you that the cost of coal, the source of energy, is only some 20 per cent of the price paid for electric power. It follows that if atomic energy were free, which certainly will not be the case, the reduction in electric power bills would hardly be enough to notice.

Economics and Atomic Power

During World War II we constructed a half-billion dollars' worth of plants for the manufacture of synthetic rubber, and did it in record time. Now that the war is over, we can return to the use of natural rubber, which we can buy at a relatively low price, thanks to the low living standards of the natives of the East Indies. But we are now faced with the obsolescence of these synthetic plants, and we may well ask, "What should we do?" Should the government rubber plants be subsidized in order that we may retain an emergency rubber-producing capacity of use in case of a national emergency? Can such plants be placed in a stand-by condition and be operable years later? Are the butylenes, required in the manufacture of synthetic rubber, waste by-products of the petroleum industry, or does their use cut into our dwindling petroleum reserves? Should we take advantage of the native who will send us rubber in return for two bowls of rice each day? These are questions for United States citizens, and they are very live ones today. They are all practical problems stemming from our technological progress.

For a number of years we have heard depressing estimates of the petroleum reserves of this continent. Fifteen years ago it was estimated that we would be out of oil in 15 years, and perhaps we have heard the cry "wolf" too often, for few of us seem to be worrying. Mr. Krug, Secretary of the Interior, who is definitely worrying, recommends the construction of a new synthetic gasoline industry which would take years to build, and would cost nine billion dollars. Does such a proposal as this make sense? Are we really almost out of oil? Should we make gasoline from coal, or from oil shale, or from natural gas? If it is a good idea why aren't the oil companies doing it? Are the processes to be used well established in laboratory and pilot plant, or would the new plants become obsolete soon after completion? Are the 18,000,000 tons of steel needed for plant construction a small or a large item in our economy?

These are important matters of national concern, but I do not mean to imply that each of us need be well informed as to the technical details of such questions, many of which must be solved by Congress or by other government groups. Nevertheless, individual citizens should have some basis for judging not only the proponents of plans to solve such problems, but the arguments on which the plans are based. They should, for example, read Mr. Krug's proposal with some understanding, not judge it on the basis of their reaction to Mr. Krug's picture in the newspaper.

So that Rational Judgment May Be Possible

Nor do I plead for science and technology as a part of a general education solely that adults may better understand national questions. Anyone who invests money or starts a business needs much more general knowledge of technology than was required a generation ago. Should the young graduate go into his father's wool business, or is it really true that good synthetic wool is "just around the corner," and that its production will make his importing business obsolete, along with the continent of Australia? The other day a cousin wrote me about an inventor he had met in Nebraska. It was reported that this man had developed a sort of radio set with an antenna capable of extracting enough electricity out of the clouds to light six 30-watt electric light lamps. On the basis of this communication, should I cash my war bonds and buy stock in this development, or am I sound in advising my cousin that the inventor is doubtless misguided? Fifty years ago people didn't buy toothpaste because it did or didn't contain irium – in fact, they didn't buy toothpaste. But today they buy it solely on its advertising claims, without knowing what irium is. To be sure, the science course in college won't provide immediate answers to problems such as these, but it will suggest a general method of getting together the best available information, so that a rational judgment may be possible.

A few weeks ago several ladies representing a temperance organization visited the president of a large chemical company to protest the marketing of a new product, hydroabietyl alcohol, which the company manufactured. To them hydroabietyl alcohol was alcohol, and alcohol was bad. Had the general education of these well-meaning ladies included some science such confusion might have been avoided and their visit would never have been undertaken. During World War II we made 500,000,000 gallons of ethyl alcohol a year. This is the equivalent of two cocktails every day in the year for every man, woman, and chlid in the United States. If drinking in this country has reached such a point, shouldn't we all join the Women's Christian Temperance Union? The difficulty

(*Continued on page 124*)

Early Chinese Rockets

Probably as Early as the Thirteenth Century, but Certainly by the Seventeenth, Chinese Ingenuity Had Adopted Rockets to a Variety of Special Military Uses

By **TENNEY L. DAVIS**

THE date of the first use of rockets for military purposes is not known with certainty. The Kin Tartars, defending Lo-yang and K'ai-fêng-fu against the Mongols in 1232, are reported to have used "flying fire spears" which by some have been taken for rockets. The Sung historians state that these devices "burnt forward with a sudden flame to a distance of 10 paces and upwards, so that no one durst approach them." Thus, the historical record practically proves that the devices were not rockets at all, for 10 paces is an unreasonably short trajectory for a rocket, more like the distance through which a Roman candle would throw its fire.

The *Wu Pei Chih* (*Treatise on Military Equipment*)[1] by Mao Yüan-i, written about 1621, contains much information about early Chinese military pyrotechnics and many clear, unequivocal pictures, among them pictures of spears equipped with tubes for spouting fire forward in the direction of the spear point, and rocket-propelled arrows capable of flying for 300 or 400 paces. We conclude that the use of rockets at Lo-yang and K'ai-fêng-fu is not proved by the texts which make reference to "flying fire spears."

There are, however, certain evidences which indicate that rockets were probably already known by the middle of the Thirteenth Century. Roger Bacon and Marcus Graecus, both of whom were writing at about this time, describe what appear to be firecrackers and toy rockets, and the title of the latter's *Liber Ignium ad comburendos hostes* (*Book of Fires for Burning the Enemy*) suggests that he considered his contrivances to be adaptable to warlike uses.

In any case, at the time when the *Wu Pei Chih* was printed, the Chinese had already developed great skill in the tactical use of rockets and were far ahead of the Europeans in their military application. Rocket-propelled arrows (Fig. 1) with razor-sharp heads, sometimes poisoned, sometimes carrying incendiary charges, were uniquely qualified for special jobs of offense and defense, for setting fire to enemy installations, for attacks from ambush, for the defense of defiles and gateways.

[1] A considerable amount of material from it has been translated into English by James R. Ware, published with reproductions of 44 of the original pictures, and discussed by Tenney L. Davis and James R. Ware in a paper on "Early Chinese Military Pyrotechnics," *Journal of Chemical Education*, **24**:522–37 (1947).

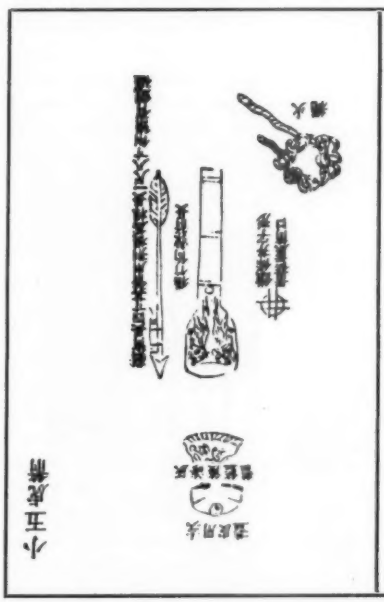


Fig. 1. Rocket driver tube, shown singly with its central cavity, and shown attached to arrow with the fuse running throughout its length.

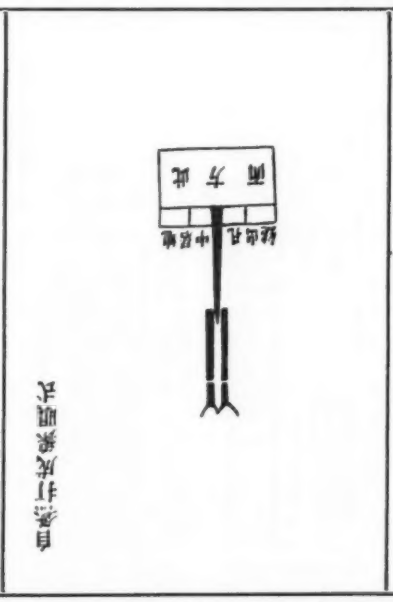


Fig. 2. Tool for making the central cavity in the rocket's propelling charge "does a better job than the drill preferred by the artisans. If the rocket-arrow is to fly straight, the hole must be straight, otherwise it will go off at a tangent."

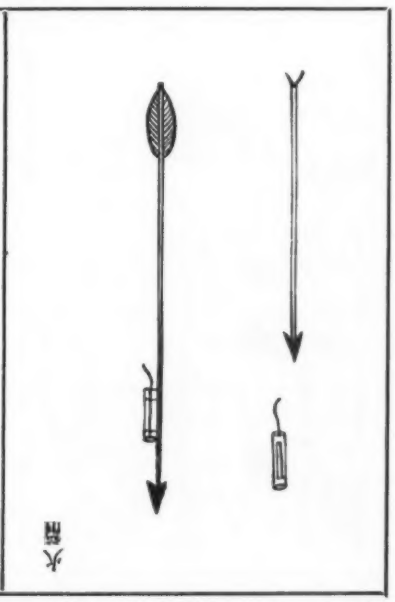


Fig. 3. (Above) *Quiver for carrying several rocket-arrows.*

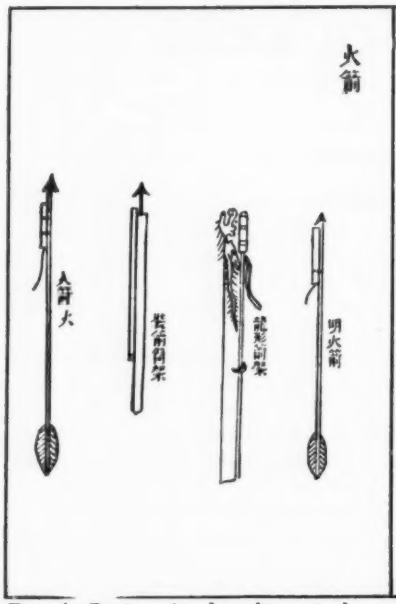


Fig. 4. Devices for launching single rocket-arrows. In one instance the rocket is launched from a tube; in the other, it is fired in the open while the stick is held in position by a loop or ring passed around it.

Fig. 5. Rocket-arrows in tubes, each connected by a fuse (match) to a single master match by which they may be fired simultaneously. The tubes are gathered together into a bundle for firing the cluster.

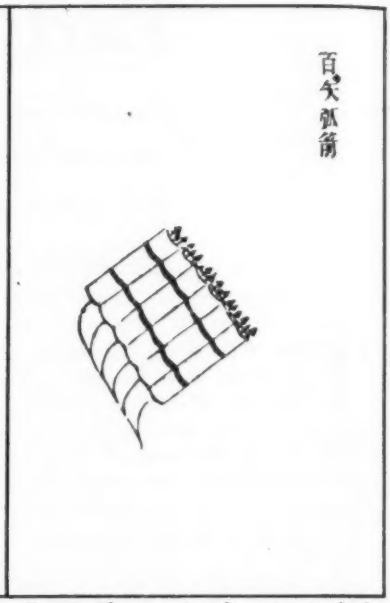


Fig. 6. Clusters of rocket-arrows which are fused for ripple or successive firing. When the master fuse or match is lighted, the arrows in each of the individual clusters fire one another in a successive array.

The *Wu Pei Chih* contains many pictures[2] of rockets for various military purposes, of devices for making them (Fig. 2), carrying them (Fig. 3), and for launching them singly (Fig. 4) and in clusters. Clusters were made up of bundles of tubes, each tube serving to launch one rocket (Fig. 5), or they were made by enclosing many rockets in a single container (Fig. 6) where the sticks were held in position and separated from one another by splints or by passing them through holes in the frames. The driver tubes in back of the heads were counterbalanced by iron weights behind the feathers of the tails.

Incendiary rocket-arrows were fired from baskets made from split bamboo, four feet long, and wider at the open end than at the bottom. The baskets were covered with paper brushed with oil for protection

[2]Reproductions by permission of the Library of Congress.

(*Continued on page 120*)

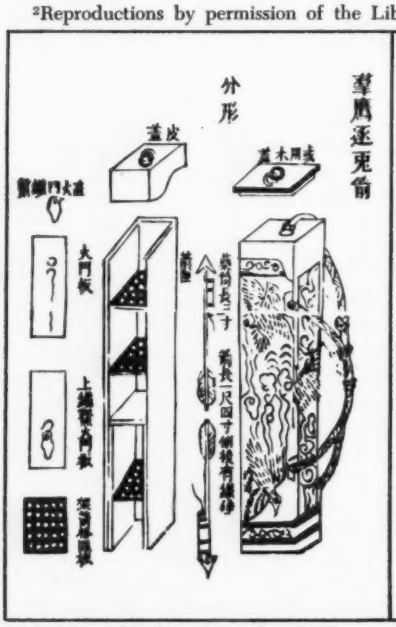


Fig. 7. Portable box of wood or leather containing two sets of 25 rocket-arrows. The sets are arranged to be fired separately, enabling a soldier to meet two emergencies for close fighting.

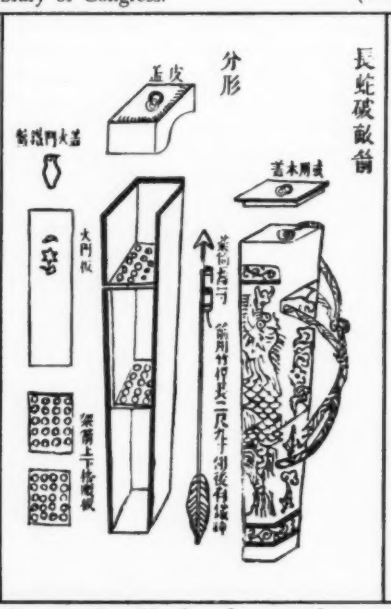


Fig. 8. Portable launcher for firing rocket-arrows against an enemy at 200 paces. Total weight, five or six pounds. The arrows are of bamboo, and points are smeared with poison.

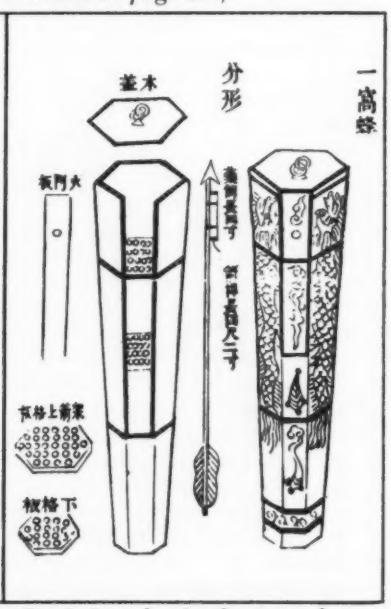


Fig. 9. Launcher for shooting a shower of rocket-arrows to a distance of 400 paces or more. The open end is enlarged so the rocket-arrows will spread out in flight to cover a large area.

André-Marie Ampère—

IMMORTALIZED BY A GERMAN

In Proposing a Name for the Unit of Electric Current
Helmholtz Perpetuated the Name of the French
Founder of the Science of Electrodynamics

By **DAVID** *and* **CHARLOTTE B. LANDAU**

IN the ancient city of Lyons which, at the time of the Romans was the capital of Gaul, André-Marie Ampère was born 173 years ago. At the time great minds flourished in all domains of learning, but especially in the early development of modern science. On the Continent, and particularly in France, Cauchy, Lagrange, Laplace, Legendre, and Poisson were foremost in the brilliant array of stars in the mathematical firmament. In the physical sciences, Fourier and Carnot in France were laying the foundations for thermodynamics, and Watt in England and Count Rumford in America were making practical applications of new theories of heat. In chemistry, Lavoisier in France discovered a gas, to which he gave the name, oxygen, during his studies of the atmosphere, and Davy in England determined the composition of water by electrolysis. Dalton in England made the first contribution to experimental evidence in support of the atomic theory of the structure of matter, and, in Italy, the laws of gases were being enunciated by Avogadro. In the intriguing and burgeoning science of electricity, Arago, Biot, Coulomb, and Du Fay in France, Priestley and Cavendish in England, and Franklin, in the American colonies, were among the foremost experimental workers of the period.

Paradoxically, the intellectual stimulation of the last half of the Eighteenth Century was also an epoch of political turmoil and national revolutions. In 1775 the American colonists declared their independence of England and gradually became welded into the United States of America. Taking their example from the American colonists whom they had aided in their struggle for freedom, the French commenced to liberate themselves from tyrannical oppression. The struggle for individual freedom was common in both cases; yet it frequently happened, as Lavoisier found out, that the political events of the time played havoc with intellectual advancement. In a less drastic measure, the life and work of Ampère likewise was shaped by events of the era in which he lived. The hardships of his life and the significance of his work can be better understood when presented against a background of conditions and events in France during the last quarter of the Eighteenth Century when Ampère was in the formative years of youth and early manhood.

In France the intellectual elite of the Eighteenth Century, like the public, had become disgusted by the corruption of the Court of King Louis XV, and its acolytes. Men of the pen began to knead the public's mind by writing against the abuses and authoritarian principles which their rulers forced on them. Voltaire, Montesquieu, Rousseau, the Encyclopedists and the physiocrats, disciples of Quesnay, all worked to create a public opinion demanding political and economic liberties. Thus, when King Louis XV died in 1774 and a change in rulers was imminent, the joy of the populace was overwhelming.

Louis XVI, a fine hearted, fine minded youth of 20 (who, unfortunately, lacked energy) came to the throne a year before Ampère was born. It was during this King's reign that the Treaty of Versailles was signed in the King's Palace – the Palace of Versailles – in 1783. Benjamin Franklin was one of the negotiators of the Treaty of Versailles, known to Americans as the Treaty of Paris, in which the English Cabinet recognized the sovereignty of the United States, thus ending the American Revolutionary War. The signing of such an important document added luster to the regime of Louis XVI, but, in spite of all, things did not go as desired and disorder became rampant.

In 1790, uprisings took place in Lyons, birthplace of Ampère, but were soon repressed. Lyons was a Royalist center and its inhabitants were opposed to the Revolution. Its great silk mills (with some 30,000 workers) and other rich industries supplied their products to the Court and the nobility. Those who were in sympathy with the Revolution were treated as enemies and handled as such. As they often do in such cases, matters went from bad to worse, and foreign soldiers had to be called in to protect His Majesty. This move hastened his downfall, and soon came the gruesome end: Louis XVI was beheaded on January 21, 1793.

When the Revolution spread from Paris to other large cities in 1793, the inhabitants of Lyons became more daring, and fearing no more the result of their Royalist acts, raised the white flag of revolt on the hilltop of Fourvière. They erected fortifications, formed an army at whose head they placed the *émigrés*, and decided to fight against the Revolution to a finish. And what a terrain they had for a battle! Let us take a glance at the emplacement.

At the time of the Revolution, an old sanctuary stood high above the Saône River. It is now supplanted by the basilica of Notre Dame de Fourvière, whose interior is bedecked with mosaics, oil paintings,

Flore

The home of André-Marie Ampère at Poleymieux a few miles from Lyons, where Ampère spent much of his boyhood, has been reconstructed and made into a museum.

and gold. The view from one of its towers offers a vast and limitless panorama, in the center of which lies the city of many bridges, Lyons. From the bottom of the giant bowl, rise the snowcapped heavenly Alps, while just 100 miles beyond rises the highest mountain of Europe, majestic Mt. Blanc. To the right, more mountains are draped in colors defying description, and to the left may be seen the valleys of the Rhône and Saône, their rivers flowing like a stream of quicksilver in the warm sunlight.

It was in Lyons that Barrère fought the Royalists and said: "The name of Lyons must exist no more. You will call it the Liberated Town, and on the ruins of this infamous city there will be erected a monument which will attest to its crimes and punishments committed against the friends of Liberty. These few words will tell it all; — Lyons warred against Liberty, Lyons is no more."

To realize the above wish, the Committee of Public Safety sent into the unfortunate town three of its representatives who shot or guillotined its inhabitants and destroyed their homes. As is the way of all revolutions, Lyons was turned into a town of horror. Such was the atmosphere in which Ampère spent his youth and early manhood.

Early Life of Ampère

On January 20, 1775, a boy was born in the city of Lyons, France, and two days thereafter was baptized André-Marie Ampère. Until he reached the age of seven, his parent lived in Lyons most of the year, passing the summer months at Poleymieux, a village situated about nine miles north of Lyons, via Saint Didier where his father had a small estate.

Poleymieux, located on the northern flank of the Mont d'Or is surrounded by and blended into a pleasant and colorful country bedecked with numerous white villas. From its heights one can see the graceful Saône River winding in and out as it courses along the valley below. The Ampère house still stands; its terrace planted with the very same linden trees under which Ampère often sat. The view, looking toward the church, is magnificent. It was here, in Poleymieux where André Ampère passed most of his youth.

Ampère's father Jean-Jacques Ampère, was a merchant, a gentleman, a scholar, and a justice of the peace. Upon reaching his 49th year, in 1782, he retired to his estate in Poleymieux. There were no schools in that village so, taking the boy in hand, the father taught him reading and writing in his own language, which he supplemented later by lessons in Latin. In addition to these lessons, André read and even memorized several parts of the *Encyclopedia,* as well as Thomas' *Élogé de Descartes.*

Up to the age of 13, his education was mostly literary to which his father added a variety of other lessons "on many things" during their long walks in the country. In this manner, the diversified knowledge of the young man grew. Ampère tells us that in 1788, the *Elements of Mathematics* of Rivard and Mazéare fell into his hands and all other subjects were forgotten. These works were soon followed by studies of Clairaut's algebra and the treatises on conic sections by La Chapelle and the Marquis de L'Hôpital. André attempted to write a treatise on conic sections for which he believed he had new and original ideas. However, when he tried to read the articles on mathematics in the *Encyclopedia,* he soon discovered that his mathematical knowledge was not sufficiently advanced; he did not know the calculus.

While on a sojourn with his father in Lyons, André made the acquaintance of Abbé Daburon, Professor of Theology at Trinity College of Lyons, who was also

an able mathematician. He told Professor Daburon that he could not make headway in mathematics since he was at a loss to unravel the full meaning of the *d's* in the articles he was reading. This amiable teacher helped him out by giving him lessons in the calculus, thus smoothing the way for further studies. In addition to the work in mathematics, which he carried on under the guidance of Abbé Daburon, Ampère also followed a course in physics by Professor Mollet during the two months that he stayed in Lyons with his father. By the time Ampère reached the age of 18, and without ever having gone to school, he had mastered mathematics and worked through those two monumental pearls – Laplace's *Traité de Mécanique Céleste* and Lagrange's *Mécanique Analytique*. He did not limit himself to mathematics alone. He read everything which came in his hands that instructed the mind. He was a versatile student in Latin which he detested at first; but in due course, it became a part of him and he even composed in it. Horace made a strong appeal to him. To the story of his own love he gave the Latin name of *Amorum*.

The French Revolution was to have a profound influence on the Ampère family. After it had calmed down in Paris, the Revolution spread to the provinces, soon reaching the town of Lyons. In his position as judge, Ampère's father took measures of precaution against the revolutionists and ordered the arrest of their leader, Chalier. This act was to be the cause of his own downfall when the revolutionists became masters of the town. The act of his condemnation, which sent him to the scaffold, read: "Justice of the Peace who issued the warrant for the arrest of Chalier." He was guillotined on November 23, 1793. The news, transmitted shortly after to his son, struck this boy of 18 like a bolt of lightning, incapacitating him for over a year. How much the father thought of the son may be judged from a letter he addressed, in perfect serenity, to his wife the day before the execution; in it we read these prophetic words: "As to my son, I expect everything from him . . ." How right his father was!

A book by Jean Jacques Rousseau, said to have been on botany, but which we believe may have been his *Émilé* fell into Ampère's hands. Its style, charm, and even the theme seemed appropriate for his melancholy needs at this period. This book was perfectly tuned to the surroundings of Poleymieux and with the two elixirs of life – youth and hope – helped to restore André's health. Ampère became fond of botany, and who would not after reading *Émilé*? He devoted himself to outdoor studies and exercises and made long trips to collect specimens for his herbarium.

In September, 1795, at the age of 20, André was working on a universal language. In October he was experimenting with a multiplatform kite on which he intended to place instruments to study atmospheric electricity, air temperatures at high altitudes, and so on. In December he designed an instrument intended to make astronomical observations without having to correct errors due to refraction, and without the use of a clock. Pupil of the school of poverty, he had will power, and by ceaseless effort showed what could be accomplished by willing human hands. He made much of the apparatus needed for his studies. Many

Blanc et DeMilly

In the quiet serenity of this garden in Poleymieux, Ampère pursued his early studies in mathematics and science, thereby laying the foundation for his monumental work in the field of electrodynamics.

pioneers in French science carried on research without endowed laboratories and sometimes even without special tools or instruments except those of their own making. Ampère was one of these versatile pioneers of the Nineteenth Century.

Romantic Years

It was during one of his botanical excursions, on April 10, 1796, that he met Julie Carron, who, on August 6, 1799, three years later, became his wife.

For Ampère it was a case of love at first sight. On August 6, the religious ceremony took place, and on August 7, 1799, "the President of Municipal Administration of Nord, Canton of Lyon, certified having seen appear before him, at the place where the Citizens' Meeting was held, André-Marie Ampère, 'mathematician,' and Catherine Antoinette Carron, who stated to him in firm and intelligible voices that they were freely and voluntarily taking one another in marriage."[1] Ampère was 24 and Julie almost 26.

After their marriage, as well as before, Ampère gave private lessons. So modest was their combined income and trying were their struggles to make ends meet that Julie wrote her mother in her very first letter: "The more I know him, the more do I find him kind and sensible. With a little fortune, everything would go well."

A year after their marriage, on August 12, 1800, a son was born. This blessing threw an extra burden on Ampère's pecuniary needs and forced him to seek a

[1] *"le président de l'Administration municipale du Nord, canton de Lyon, certifiait avoir vu comparaitre devant lui, au lieu de la réunion des citoyens, André-Marie Ampère, 'mathématicien,' et Catherine Antoinette Carron* (this was her real and official name), *lesquels lui ont déclaré à haute et intelligible voix se prendre librement et volontairement pour époux."*

The Ampère home has now become a museum where visitors may see the personal and scientific effects of André-Marie Ampère, his father, and his son.

Société des Amis d'André-Marie Ampère

more lucrative source of income. Prior to his marriage, Julie's relatives had suggested that André become a business man, but this was far from Ampère's desire to become a teacher. Teaching was in the blood. Now came the ill health of his wife, and that obliged him to carry on still more work.

On February 19, 1802, he obtained a chair of physics and chemistry at the École Centrale of Bourg-en-Bresse, in the department of Ain. This school, at Bourg-en-Bresse, had a long and famous history dating back to 1391! It went through many changes and enlargements. In 1661, a chair of philosophy was founded there, and in 1744 it became the center of intellectual life inspired by the famous astronomer, Joseph Jérôme Lalande, who was born in Bourg. In 1793 the college was closed, but later it was reopened under the name of École Centrale, which was again changed, in 1805, when the school became the Lycée Lalande. Ampère was a professor at the École Centrale from April, 1802, to 1803. He was forced to live in Bourg which was but 60 kilometers from Lyons. In Ampère's day, it required one and a half days to make the trip; today it takes about one and a half hours. Here, in his own words, he tells us by a letter which he sent his wife, how he lived in Bourg:

I am boarding for 40 francs per month at Beauregard's. They charged me 60 francs at the inn, where I had to dine in the company of the biggest fools I have seen in my life. That surpasses all possible description . . . I saw the physics room, the chemistry laboratory and the single small room with an alcove, catch-all serving as a small woodshed. I was very pleased with the machinery; the laboratory is equipped with a large exhaust-hood, vented into the fireplace, designed to vent off noxious gases; there are plenty of facilities for various experiments . . . address your letters to Citizen Beauregard . . .[2]

And Julie addressed letters to him in the following manner:

From Madame Julie Ampère to Citizen Ampère, lodged at Citizen Beauregard's, Professor of History at the École Centrale du departement de l'Ain at Bourg, near the Notre Dame church.[3]

What a document on an envelope! Ampére sent practically all his earnings to his wife; such was the soul of the great man who was as poor as the proverbial church mouse. He wrote her of his daily tasks which lasted from 12 to 13 hours in the school! Julie, in turn, consoled him with her little words of kindness. Here is one of them: ". . . let us be patient and let us rejoice that we will be able to speak at Easter about everything we have in our souls . . . My poor Ampère you are just far too pleased to send me everything you earn . . ."[4] In another one of her letters she wrote: "Look out for your chemistry. Your blue stockings are destroyed with that frightful acid which burns everything." Poor Julie! Like other daughters of France, with limited income, in ill health, and with a small child to care for, she probably darned many a blue stocking.

Ampère wanted to be near his family and decided to become a professor in his own town of Lyons. How could he make this want known to the authorities? With a professorship as a goal he decided to write a treatise of some kind that would attract attention of the academic public. For some time Ampère had drawn the attention of the scientific world by his purely mathematical work and so deep was he intrenched in that science that, even his wooing was, at

[2] *"Je suis en pension à 40 francs par mois chez Beauregard. On me demandait 60 francs à l'auberge, où il fallait manger avec les plus sottisiers que j'aie vus de ma vie. Cela passait toute expression. . . . J'ai vu le cabinet de physique, le laboratoire de chimie et l'unique petite chambre avec alcove, petit débarras a mettre le bois. J'ai été fort content des machines; le laboratoire a un grand manteau de cheminée par où doivent s'exhaler les vapeurs nuisibles; il y a assez de ressources pour les differentes expériences . . . adresse tes lettres au citoyen Beauregard. . . ."*

[3] *"De Mme. Julie Ampère au Citoyen Ampère, chez le Citoyen Beauregard, professeur d'Histoire à l'École Centrale du département de l'Ain, à Bourg, pres de l'Église Notre Dame."*

[4] *". . . prenons patience et réjouissons nous de pouvoir parler à Paques de tout ce que nous avons dans l'âme . . . mon pauvre Ampère, tu es trop content de m'envoyer tout ce que tu gagnes. . . ."*

Ampère's library is kept much as it was more than a century ago when he was professor of physics at L'École Centrale in Bourg-en-Bresse.

Société des Amis d'André-Marie Ampère

times, a little mathematical. He tried to teach Julie Carron how to calculate the height of a village steeple, and history tells us he met with success!

In 1802, he wrote a memoir which he called *Considérations sur la théorie mathématique du jeu.* Following in the steps of Pascal and Fermat, this paper dealt with the mathematical theory of gambling and was presented to the Institut by Delambre on January 12, 1803. "The players," said Ampère, "see only the effects of chance in these events which are most apt to teach them the extent of the dangers into which they throw themselves. These events might make a deeper impression on their minds if one could demonstrate that they are facing a combination of good and bad chances, and the only way to escape the misfortune is to cease exposing themselves to it." He gave such a learned proof of his theoretical reasoning that it could be understood only by an able mathematician. His memoir which should have been finished in "a day or two" took 10 months to be completed! It was examined by several persons, including Lalande, but none could understand it. Lalande was already too old and lost his ideas of analytics and its application to probabilities. But he said in a short report: "Citizen Ampère possesses rare knowledge and marked talent." Finally, Laplace examined it at the request of the Institut. He found an error which Ampère corrected. Ampère then submitted it to the one man who could understand it – Delambre – who had been one time a pupil of Lalande.

Delambre was so impressed by Ampère's work that he persuaded Bonaparte, who was then first consul, to name Ampère professor of mathematics at the Lycée of Lyons in 1803. He was appointed to the post and taught for a short time in that gruesome cloister which was to bear his name later. Thanks to this appointment, he was now able to join his family, although his happiness was short-lived. Julie, who had been ailing for some time, now grew worse, and died on July 13, 1803, The shock of her death overwhelmed Ampère and life became dismal without his companion. Ampère became a broken man and decided to leave his beloved Lyons.

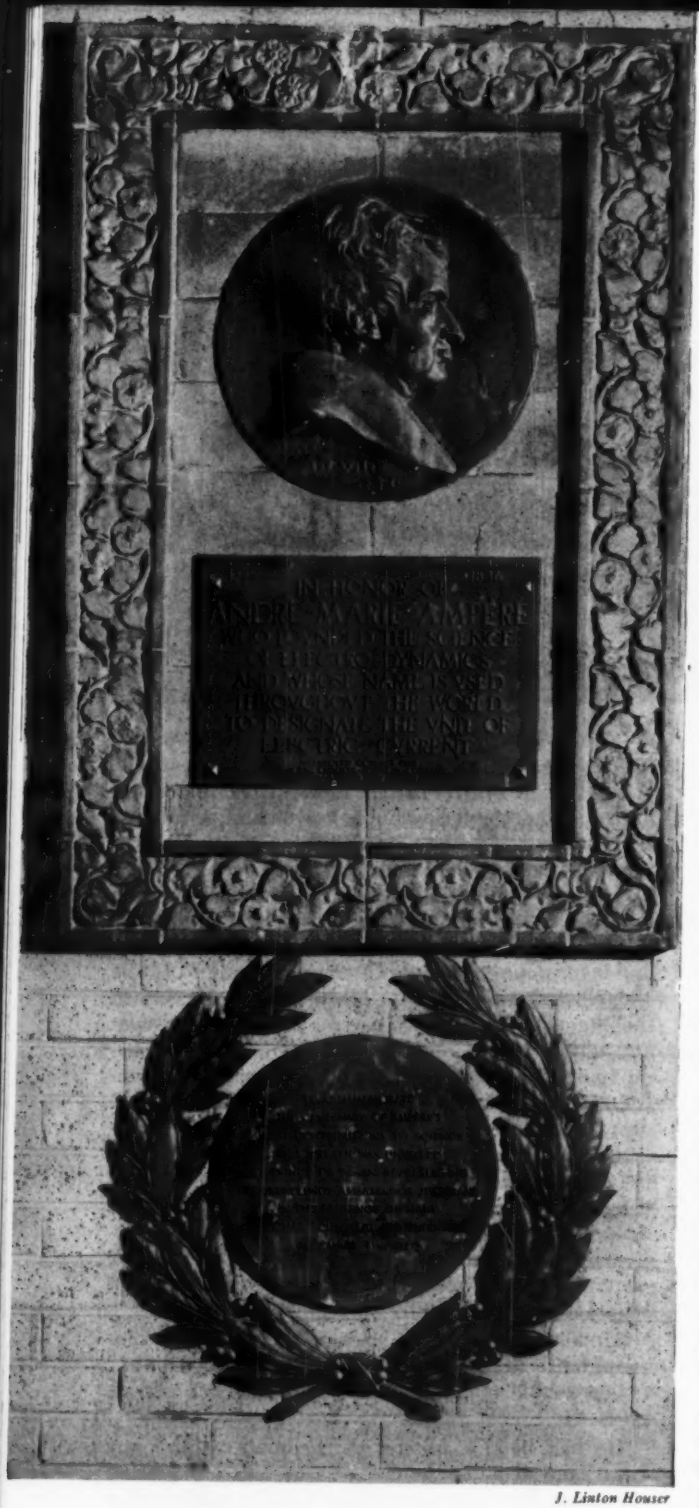
In October, 1804, at the age of 30, he was appointed to the newly established École Polytechnique in Paris as *répétiteur d'analyse* or assistant in calculus. In March, 1806, he was named member of the *Bureau Consultatif des Arts et Métiers,* and in 1807, became *professeur suppléant d'analyse* or substitute professor of calculus. In 1808, he was named entrance examiner and *inspecteur général de l'Université,* and in 1814 he was elected a *membre de l'Institut.* Membership in the French Academy, which is a part of the Institut and which Henry Crew[5] describes as "a coterie of productive scholars perhaps never surpassed either before or after," was a coveted honor which Ampère well deserved. In the same year he was also made a *Chevalier de la Légion d'Honneur,* while 1816 brought him the full title of professor of calculus and mechanics at the École Polytechnique. It was in this school that Ampère performed his famous experiments in electrodynamics. Finally, in 1824, he was elected to the chair of physics at the *Collège de France,* which high post he held to the end of life.

Ampère was a man of science but he was also intermittently at least, a man of religious faith. "Doubt," he once said, "is the greatest torture Man can endure on Earth."[6]

He had been a sufferer of rheumatism for many years, and at 50 he developed a chronic affection of the chest, but frequent visits which he made to the Mediterranean usually helped to restore his health. In 1829 he began to ail seriously and was replaced in his teaching at the *Collège de France* by Savart for one year. He returned but had to give up again and was replaced by Savart and Becquerel in 1832–1833. In

[5] "Portraits of Famous Physicists with Biographical Accounts," *Scripta Mathematica* (New York: Yeshiva College, 1942).

[6] When he was at Bourg he asked his wife to send him certain religious books and he went to church often. His mother was very pious.



J. Linton Hooser

The plaque and inscription above, in the railroad station at Ampere, N.J., remind American commuters of their debt to the brilliant intellect whose treatise on electrodynamics, as presented before the French Academy, was developed in the remarkably short period of about two months.

May, 1836, during a journey of inspection to Marseilles he was seized with illness and died there on June 11, 1836. He was in his sixty-second year. His remains were transferred to the cemetery of Montmartre in the city of Paris in 1869.

It is, perhaps, difficult to evaluate the life of such an outstanding intellect as Ampère in the light of our present, and detached, point of view. And yet how little difference two centuries make in human nature!

In the words of Rollo Appleyard, Ampère may be quite properly described as one given to "plain living and high thinking." Ampère was financially a poor man, yet he bore honors and titles bestowed only upon the highest of intellectuals of France. And what a galaxy of titles Ampère had earned: *Membre de l'Institut, Professeur de l'École Polytechnique,* and *Inspecteur Général de l'Université* among them. But for all his intellectual attainments and honors, Ampère was hampered in his research – as indeed also in his private life – by the small income which he received. With all his titles, Ampère was so reduced in his finances that he had to supplement his income by private teaching. Even such additional effort was not sufficient to fulfill the needs of Ampère who lived simply all his life and kept expenses to a minimum. It is recorded, for example, that Ampère once borrowed 50 francs from Fresnel to pay part of his household expenses. In 1824, his sister Josephine (who kept watch of his budget to free Ampère from household worries) admitted a debt of 11,000 francs which she had contracted during the previous five years. Most of this amount had been spent for instruments needed in scientific experiments, but the indebtedness had been kept from Ampère.

In personal demeanor, the modest Ampère was indifferent to fame. This is shown by the fact that he wrote and published a work on the differential and integral calculus to which he did not even attach his name. May we not be justified in believing that perhaps Ampère wished to make available to others the knowledge of calculus which he, in turn, had received through the kindness of Abbé Daburon?

As for his scientific work, Ampère was so advanced that contemporary French physicists were prone to criticize him, even suggesting that his theories were not in accord with Newton's laws. Of the elite members of the French Academy, Fourier alone received Ampère's theories favorably. In England few men understood his theories and still fewer his analytical work. Yet, a quarter century after Ampère had so brilliantly established the field of electrodynamics, Maxwell, in England, summarized the work of Ampère into the circuital law of Ampère – one of the four foundations of modern electromagnetic theory.

Ampère's mind seemed to know no bounds, and, as might be expected, he made contributions to many sciences. He contributed to the initial idea of the electric telegraph by directing attention to an idea suggested by Laplace that it might be possible to cause a magnetic needle to deflect at great distances by means of an electric current. He also came near to being the discoverer of iodine. His memoirs show his work covered such subjects as transcendental mathematics, Mariotte's law, electricity, magnetism, optics, molecular physics, animal physiology, psychology, theory of gases,[7] mechanics, theory of terrestrial magnetism,

(*Continued on page 126*)

[7] Ampère's law was formulated independently in 1814, although Avogadro's law had been announced in 1811.

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

For the Record

BUSINESS was the order of the day at the 264th meeting of the Alumni Council held at the Campus Room of the Graduate House on October 25, with C. George Dandrow, '22, President of the M.I.T. Alumni Association, presiding. At this meeting, which opened the season's activities, 129 members and guests were present.

Reports by committees on resolutions for the late Professors C. Frank Allen, '72, Class Representative on the Council, and Charles E. Locke, '96, Secretary of the Alumni Association, were presented by Professor Erwin H. Schell, '12, and Dr. John A. Rockwell, '96, respectively. The resolutions were adopted by a standing vote in tribute to these two outstanding Technology Alumni.

The resolution on Professor Locke, prepared by the committee under the chairmanship of Dr. Rockwell, read, in part: "As a teacher and member of the Institute's staff for forty years, he will long be remembered by associates and students alike for his thoroughness and sense of responsibility in the handling of all tasks. As a mining engineer and author, he was well known and highly regarded for his many contributions in methods of processing ores. As Secretary of the Alumni Association from 1930 to 1948, and particularly as Secretary of the Council, he has earned the gratitude and appreciation of each and every member by conducting his work faithfully, efficiently and pleasantly. As Secretary of the Class of 1896 from 1908 to 1948, he was known and loved by all."

H. E. Lobdell, '17, reporting for the Executive Committee, announced that Donald P. Severance, '38, associated with the Office of the Registrar since his graduation from M.I.T., and Assistant Registrar since 1941, had been elected secretary of the Alumni Association to fill the unexpired term of the late Professor Locke. Mr. Severance was simultaneously elected treasurer of the Association to succeed Ralph T. Jope, '28, who had resigned to accept the assignment of assistant executive director of the Corporation Committee on Financing Development, as recorded in greater detail on page 110 of this issue.

Edmund B. Fritz, '32, was reported to have been appointed chairman of Alumni Day, to be held on June 11, 1949. It was also reported by Mr. Lobdell that the Midwinter Meeting of the Alumni Association would be held at Walker Memorial on February 5, 1949. The chairman for this meeting will be George E. Shrigley, '30. Also reported were visits by 21 Faculty members and alumni members to 14 M.I.T. clubs between the dates of June 1 and October 25. Henry B. Kane, '24, Director of the Alumni Fund, reported that 8,000 Alumni had contributed $117,000 to the Fund as of October 25.

Dr. Compton addressed the Council in his new role as chairman of the Corporation, dealing with those events which led to the establishment of the Institute, the recent appointment of himself as chairman of the Corporation and James R. Killian, Jr., '26, as his successor to the presidency of M.I.T., and speaking briefly on the Institute's Financing Development Program now getting under way.

Professor William L. Campbell, '15, who has taken on additional duties as executive director of the Corporation Committee on Financing Development, presented a résumé of the committee's program and goal, a brief outline of the various subcommittees already at work, and an indication of the activity already under way in this far-reaching program.

M.I.T. Photo

DONALD P. SEVERANCE, '38

Secretary-Treasurer of the Alumni Association

In his recent election as secretary-treasurer of the M.I.T. Alumni Association, Mr. Severance succeeds the late Charles E. Locke, '96, who served as secretary from 1930 until his death last September; he also succeeds Ralph T. Jope, '28, who has been treasurer of the Alumni Association from 1939 until his resignation from this position last month to devote a major portion of his time to the Financing Development Program as its assistant executive director.

Mr. Severance is a graduate of the Course in Electrical Engineering, having received his bachelor's degree in 1938 and his master's degree in 1941. He has taught courses in Electrical Engineering, and since his graduation a decade ago Mr. Severance has been associated with the Registrar's Office. He leaves his position as assistant registrar to devote full time to the rapidly expanding activities of M.I.T. clubs, now numbering 85, and to the Institute's alumni body.

M.I.T. Photo

RALPH T. JOPE, '28
Assistant Executive Director

M.I.T. Photo

WILLIAM L. CAMPBELL, '15
Executive Director

Actively participating in the administration of the Institute's Financing Development Program, which was officially launched at a meeting at Technology on November 19–20, are the two M.I.T. Alumni shown above. In addition to his duties as head of the Department of Food Technology, Professor Campbell has been appointed executive director for the Program whose objective is to raise $20,000,000 for new construction, additional endowment, and unrestricted funds for the Institute.

Mr. Jope's new position as assistant executive director for the Financial Development Program has made it necessary for him to relinquish his position as treasurer of the M.I.T. Alumni Association, a post which he has filled with distinction since 1939. This advancement will result in no changes in the personnel of this periodical, for Mr. Jope continues to serve The Review as its business manager, as he has done for the past two decades.

As chairman of the Committee on Alumni Participation in the Financing Development Program, H. B. Richmond, '14, explained the relationship of the Alumni Fund to the new Financing Development Program. It was pointed out that the $500,000 contribution of Alumni for the completion of the new Senior House was already one way in which the Fund had aided the Financing Development Program, and that the Alumni Fund would be exceedingly helpful in achieving the objectives of the Program.

Mr. Dandrow then introduced Dr. Killian for his first appearance before the Council in his new role as president of M.I.T. Dr. Killian paid tribute to his predecessor and commented on his rise from student editor to his present post. He recounted some recent developments of the Institute by enumerating the activities and problems of four offices of administration: Admissions, Registrar's, Treasurer's, and Dean of Students.

Financing the Development Program

NEARLY 200 Alumni and friends of the Institute gathered in Cambridge on November 19 and 20 for a two-day conference to study the Institute's postwar problems and to lay plans for the formation of an organization to secure for M.I.T. its high priority postwar needs in buildings and endowment.

For more than a year the Institute's increasingly difficult postwar task of carrying a major responsibility for training many of the nation's scientists and engineers, and conducting numerous significant research programs, had been under study by the Corporation's Survey Committee, headed by John R. Macomber, '97. This committee concluded that, to maintain its foremost position among the privately endowed institutions of higher learning, the Institute would require considerable expansion of its facilities and endowment; it also recommended that a Committee on Financing Development be established to secure the funds required for underwriting the Institute's future needs. The meeting held in Cambridge was the first step in carrying out the recommendations of the Survey Committee.

The conference was officially opened by Marshall B. Dalton, '15, general chairman of the Committee on Financing Development, at a luncheon in the Campus Room of the Graduate House on November 19. He outlined the purpose and program of the conference and introduced the Institute's new President, James R. Killian, Jr., '26, who discussed the nation's need for maintaining the independence and integrity of institutions of learning.

In summarizing the reasons why the Institute needs large capital funds, President Killian pointed out that, fundamentally, the Institute's problem is to fund its

independence. It is especially important to make sure that the Institute has sufficient resources so that it is not required to look to government subsidy for conduct of its outstanding services. In outlining the basic needs of the Institute, he pointed out that the principal goals of the Institute were as follows: (1) M.I.T. must maintain its educational leadership by pioneering work in new fields and by having unexcelled facilities; (2) the Institute must broaden its educational program by providing a more rounded and complete college community for its students, almost a third of whom are pursuing graduate study, and (3) it must insure and stabilize an adequate salary level for its Faculty and staff to assure a stable corps of instructors of the highest caliber that can be obtained.

The afternoon session, also held in the Campus Room, was devoted to a detailed presentation of the needs of the Institute as set forth by the Survey Committee and amplified by members of the Administration. Everett M. Baker, Dean of Students, stressed the importance to high student morale of a pleasant living environment, and forecast the benefits to be expected from better housing and recreational facilities for the students and younger members of the Institute's growing staff. Professor John C. Slater, Head of the Department of Physics, spoke of the dire need for moving the important research and educational programs in nuclear science and in electronics out of the present wooden structures and into a modern fireproof laboratory. Professor Thomas K. Sherwood, '24, Dean of Engineering, described the work going on in the fields of gas turbines, supersonics, hydromechanics, and metal processing, and made special reference to the need for new laboratories for the programs in hydromechanics and metal processing.

Another area of research being carried out in nonfireproof quarters, improvised during World War II, is in the important field of food biology and processing. Professor William L. Campbell, '15, Head of the Department of Food Technology, outlined the needs of his Department in the Institute's program of food research and instruction. As spokesman for the nonscientific needs of the Institute, Professor John E. Burchard, '23, Dean of Humanities, made a strong case for the need of a Humanities Center as part of the new Hayden Memorial Library now under construction; an auditorium for student gatherings, and a Faculty Club were also listed as immediate nonscientific needs of the Institute. Finally, Horace S. Ford, Treasurer, closed the Friday afternoon meeting with an address on the financial problems confronting M.I.T. as it faces the future, and discussed the way in which these could be solved with added endowment and unrestricted funds. The Institute's postwar needs were estimated at $30,000,000 of which approximately $10,000,000 has been received since World War II in gifts, leaving a balance of $20,000,000 to be raised for new construction, additional endowment and unrestricted funds for M.I.T.

On the evening of November 19, the Hotel Statler was the scene of the banquet for those attending the conference. Speakers included Alfred P. Sloan, Jr., '95, honorary chairman of the Committee on Financing Development, and Dr. Compton, chairman of the Corporation.

DONALD F. CARPENTER, '22
Life Member of the Corporation

Corporation Life Member Donald F. Carpenter, '22, chairman of the United States Munitions Board, has been elected to life membership on the Corporation of the Institute. Mr. Carpenter was first elected to the Corporation for a five-year term in 1943. His election to life membership comes at the completion of this term, during which he has served as chairman of the Corporation Committee on Student Activity. Associated with the Remington Arms Company since 1933, where he is now vice-president and assistant general manager, Mr. Carpenter is in Washington on leave of absence. Mr. Carpenter has served on the Industry Advisory Committee and more recently on the Military Liaison Committee of the Atomic Energy Commission. He is also deputy to James Forrestal, Secretary of Defense, on atomic energy matters. He is a member of the Board of Directors of the American Management Association and is assistant chairman of the Small Arms Ammunition Industry Integrating Committee. Mr. Carpenter is a director of the Merchants National Bank of Leominster, Mass., the Remington Arms Union Metallic Cartridge Company, Ltd., of Brimsdown, England, the Peoples Savings Bank of Bridgeport, Conn., and the Seneca Falls (N.Y.) Machine Company.

On Saturday, the conference discussed ways and means of underwriting Technology's future. As guests of the committee, Arnaud C. Marts, President of Marts and Lundy, Inc., New York consultants in fund raising, outlined the policies and methods which have been found to be successful in securing capital funds for universities. He reinforced the confidence of members of the Survey Committee that the $20,000,000 still needed is within the likelihood of attainment in a period of about two years. At the same time, he warned that funds on such a scale as those needed by the Institute require long and painstaking efforts.

Joseph J. Snyder, 2–44, Assistant Treasurer, indicated what may be expected in the way of Corporation participation in the capital funds program. Mr. Dalton then introduced the chairmen of the various subcommittees who spoke briefly on their respective

functions in the campaign. The committee chairmen include: Alfred P. Sloan, Jr., '95, honorary chairman, and Marshall B. Dalton, '15, general chairman, Committee on Financing Development; Thomas D'A. Brophy, '16, Committee on Public Information; H. B. Richmond, '14, Committee on Alumni Participation; William L. Campbell, '15, Committee on Projects; Horace S. Ford, Committee on Resources; Frank B. Jewett, '03, Committee on Foundations; and Phillips Ketchum, Committee on Bequests. Professor Campbell is executive director and Mr. Jope is assistant executive director of the office staff having headquarters in the Institute's main buildings.

The two-day program came to a close with a luncheon in the Campus Room. Professor George R. Harrison, Dean of Science, made the concluding luncheon talk. Claiming a certain degree of objectivity because he was not an M.I.T. Alumnus, Dean Harrison chose for his topic "How M.I.T. Looks to an Outsider on the Inside" in appraising the high potentialities of the Institute and the critical part which the Development Program will play in M.I.T.'s service to society in the postwar era.

The President Reports

GRANTS from industry in support of research and advanced education at the Institute are increasing under a program in which the possibilities of cooperation with industry in fields of mutual interest are being explored. This trend was reported by Dr. Compton, as President of M.I.T., at the meeting of the Corporation on October 4. In recording progress toward objectives for the future development of the Institute, Dr. Compton recalled the work of the Corporation's Survey Committee, headed by John R. Macomber, '97, and outlined the steps which are being taken to implement that report. Said Dr. Compton:

The Survey Committee was a large and representative group of the Corporation, aided by several alumni and outside consultants. It made a thorough study of the financial resources of the Institute and of the administration's tentative list of high priority needs for additional capital facilities and resources, and it recommended the creation of a Committee on Financing Development with a "program to increase the endowment and plant of M.I.T. [which] should be a planned, scheduled and organized effort to bring the Institute to maximum effectiveness. The short-range objective is to secure [an additional] $20,000,000 over a reasonable period for immediate application to the several projects and endowment but the Committee on Financing Development should also arrange for a continuous directed effort to finance new or changed requirements as they arise in the future."

The Survey Committee then went on to suggest a proposed organization for securing these funds, as a result of its study of various tested plans and methods. It recommended a large standing committee, reporting to the Corporation, to be called the "Committee on Financing Development." It recommended the appointment of a General Chairman, a Steering Committee, a Development Office, a Committee on Projects, a Committee on Public Information, a Committee on Alumni Participation, a Committee on Resources, a Committee for Special Gifts, a Committee on Business Corporations, and a group of local committees. It also suggested the form and duties of these committees and considered the desirability of engaging the assistance of a professional fund-raising organization. The Committee's report closed with the following paragraph:

"The Survey Committee approves in principle the broad organizational outline as described here, recognizing that the complete organization will need to be devised later. This outline is intended to serve only as a preliminary guide to the chief executive of the organization. Carefully detailed preparation and organization should precede the opening of active solicitation. While the immediate effort will not be a 'campaign' or a 'drive' the organization needs to operate with a sense of urgency, and with effective publicity. All members of the M.I.T. constituency should be given an organized opportunity to contribute, even though the primary source of funds will be found in a limited number of donors." In interpreting this last sentence, we expect that this financial operation will stimulate rather than compete with contributions to the alumni and class funds within the normal scope of these funds.

Following the Corporation's approval of the recommendations in this report, the Executive Committee moved promptly to start the operation. Its first and most important move was to select the General Chairman, and the immediate approval of the selection of Marshall B. Dalton, '15, has been well justified by the vigor with which he is undertaking the organizational steps.*

There are a few general comments which I would make with reference to our fund-raising program. The first is that we are talking about postwar additions involving $30,000,000, of which approximately $10,000,000 has already been secured, leaving $20,000,000 still needed. So far as we can ascertain, this is the largest amount of money which any educational institution, with the exception of one, has ever set out to raise in an organized intensive effort, though it is far from the largest amount of money which institutions have stated to describe their needs and opportunities.

The second point is that every one of the objectives listed has been checked and studied in detail and stands every test which we can give it as being essential to our position of leadership in technological education.

The third comment bears on a rather anomalous situation in which privately supported educational institutions are found in one particular aspect of fund raising. I refer to the general attitude of the philanthropic foundations. There was a time a score or two score years ago when the foundations gave generously to the creation of needed new facilities of laboratories, libraries, and the like. Then came a reaction against "brick and mortar" and emphasis was placed on support of projects and programs, with emphasis shifting from endowment or long-term support to short-term support and with the formula that "if the project proves to be good, some other means will surely be found to continue it." Simultaneously emphasis was coming to be placed on men, rather than on either projects or facilities.

In commenting on the problems of financing which privately endowed and publicly supported educational institutions face, Dr. Compton recalled that private institutions are being more and more throttled in their efforts to obtain plant facilities and "this particular situation is one which threatens the relative effectiveness of privately supported institutions." Then, continued Dr. Compton:

Government has not found a legitimate way to provide private institutions with new capital facilities, except in certain very special cases, and industry is just beginning to justify grants for capital purposes. Foundations them-

(*Continued on page 114*)

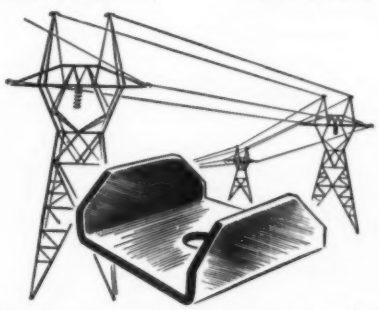
*Progress being made by the Committee on Financing Development appears on page 110.

BUSINESS IN MOTION

To our Colleagues in American Business . . .

The part shown here certainly does not seem complicated in either design or manufacture. Yet actually it proved to be difficult to make as economically as was desired. The piece is called a "potential tap," and is a small stamped channel section used in certain types of electric meters. Since it has to carry current, naturally it is made of copper.

Originally this was made of electrolytic copper, with sufficient hardness to provide the strength required to withstand the operation of tightening the wires on it by means of a nut and washer. The metal, however, proved troublesome, because cracks developed at the bends during the forming operation. As a result, 100% inspection was required, and rejections were numerous. Even though the rejects had a high salvage value, as is the case with anything made of copper, still the cost of the part was much higher than had been expected.



At this point, a Revere Technical Adviser entered the picture. He studied both the requirements of the metal and the fabrication methods, and made two suggestions. One was that a somewhat harder temper be used. The other was that the metal be OFHC Copper, Oxygen-Free, High Conductivity. Test runs on this Revere Metal proved so satisfactory that a large production order was placed.

OFHC Copper carries a premium over regular electrolytic, due to the extra processing necessary to produce it. Most of its applications are rather special, such as in electron tubes, and in electrical equipment operated at high temperatures in the presence of reducing gases. In the case of this potential tap such chemical characteristics were unimportant. The reason the Revere Technical Adviser recommended the metal was that it has excellent forming characteristics, even at a Rockwell hardness of B50. For that reason it can be deep-drawn, and the 90-degree bend required in this part is easy to produce without fracture.

The General Manager of the company expressed it this way: "We paid a premium for OFHC Copper. But that premium is much more than offset by our saving in scrap and the all-around reduction in costs. Our potential taps now have no more cracks in the bends, there are no rejections whatever, and expensive inspection has been eliminated."

Thus another manufacturer has learned that it is not the price per pound that determines the economy of a material, but the cost of the finished part made of it.

In this instance Revere collaborated with the company in the investigation. However, there are other informed suppliers of materials, whether they be metals or chemicals, plastics, glass or wood. Revere suggests that you take them into your confidence, and work closely with them. After all, every order entitles you to their knowledge as well as to their shipments. Why not get both?

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THE INSTITUTE GAZETTE

(*Continued from page 112*)

selves have as great a stake as anyone in the prosperous development of industry, for they are among the largest stockholders in free enterprise. In regard to major social problems – like natural resources versus population, national security, ability to maintain social security and standards of living and health – science and technology play roles certainly comparable to social planning or controls in any long-range view, and are clearly subordinate in importance only to ethics and religion.

Although Cambridge and M.I.T. are almost synonymous terms, the President's Report reminds us that the Institute has outside operations going on in 27 places in 11 states and in Canada. The President's Report included the following comments on special educational projects:

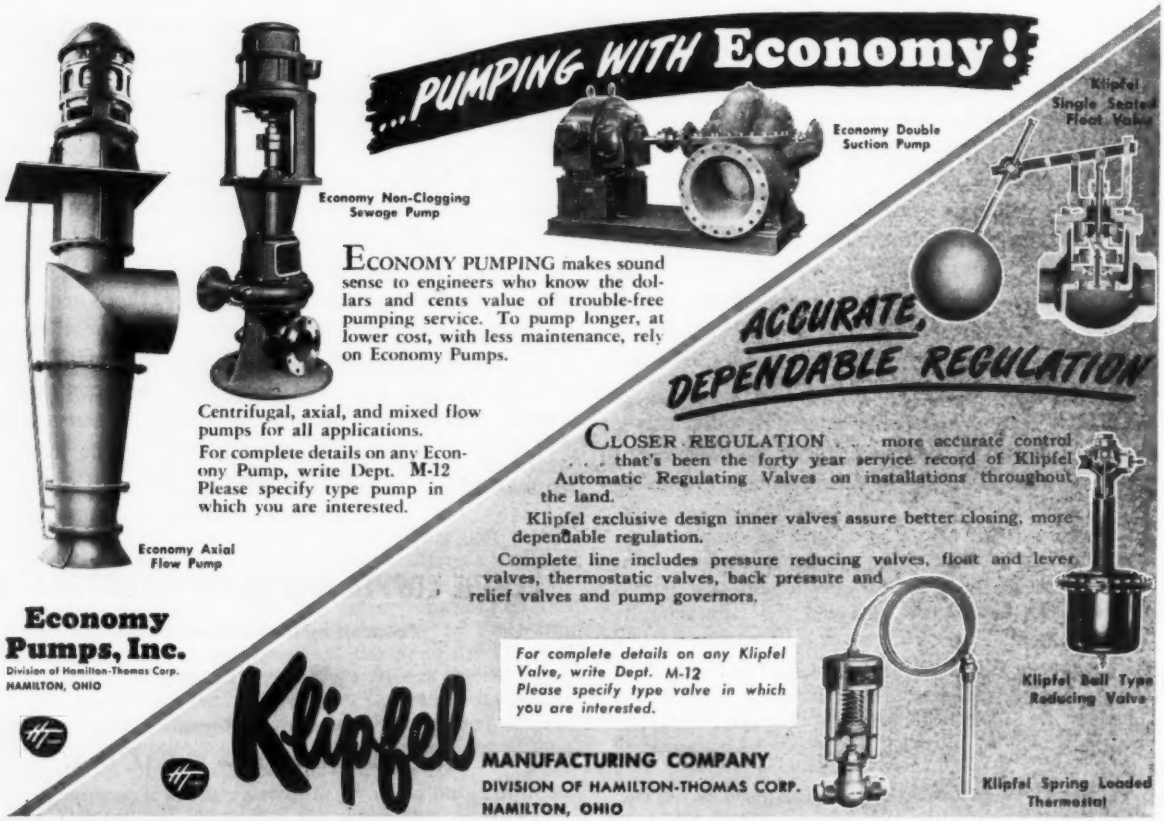
I had originally hoped to discuss at this time the report of our faculty committee on its two years' intensive study of our educational objectives and procedures. However, because of the magnitude and importance of the task, the decision was reached to postpone the report until some time in the coming year, it being felt that soundness of conclusions was far more important than a few months more or less in their timing. When this study shall have been completed we shall all feel an increased confidence and enthusiasm, whether or not the committee recommends substantial changes in our operations.

With renewed generous financial support by Alfred P. Sloan, Jr., '95, through his foundation, the Alfred P. Sloan Foundation Fellowship Program in industrial management has been reauthorized for a period of years, after having been abandoned during the war because the men who would have been involved in it were too urgently needed for war service. We are convinced, by testimony and results, that this has been the outstanding program in the country for expediting the development of promising young executives. A group of fellows will be selected during the coming months to begin their active program next summer, under the executive supervision of Professor Gerald B. Tallman. In conducting this program, our Department of Business and Engineering Administration has always had the very generous co-operation of the top executives of many business concerns in the selection of candidates and participation in seminars, plant visits, and thesis studies.

The unique program of the M.I.T. Foreign Student Summer Project was also summarized in the President's Report; a full-length article on this topic appared in the November, 1948, issue of The Review. As to athletic activities at M.I.T., the President's Report continues:

Also of real educational significance is the new program of intramural and undergraduate athletics which has been instituted under the regime of our first Director of Athletics, Ivan J. Geiger, and the new Athletic Board appointed by the President. With retention as before of the essential feature of undergraduate management of their

(*Continued on page 116*)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THE INSTITUTE GAZETTE

(*Continued from page 114*)

activities, but with the experience and advice of Mr. Geiger, emphasis has been placed on two factors: first, the attempt to interest every student in some type of athletics, and, second, substitution for the prewar freshman compulsory physical training of a program whereby every freshman, under experienced teachers, achieves some proficiency in one or more types of athletic sport which can give him continued satisfaction after leaving college. The results of the first year of this new program have been decidedly gratifying.

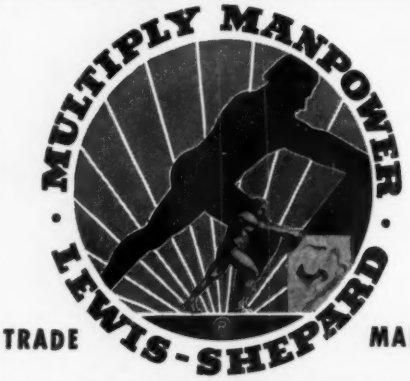
In spite of efforts to reduce the enrollment to the stabilized postwar figure of 4,500 students as soon as this becomes practicable, the student body this year is still at a very high level. Enrollment this year is 5,474 which is only slightly less than the all-time peak of 5,662 reached last year and more than the 5,000 figure which had been forecast for this year. Of last year's student body, approximately 54 per cent were veterans as compared to 60 per cent for the preceding year; and approximately 22 per cent were married, as compared with 25 per cent for the preceding year. A total of 223 American colleges and universities and 88 foreign institutions in 47 countries were represented in the Institute's cosmopolitan student body which included 67 women.

Recognizing changed conditions to be encountered in the postwar period, the Institute inaugurated an annual salary plan for its Faculty members a few years ago. The success of this plan, under present economic conditions, was summarized by Dr. Compton in these words:

The cost of living as measured by the Consumers' Price Index had risen, as of April of this year, nearly 70 per cent since 1939 – and is now still higher. Actually in American colleges increasing compensation of faculty members has fallen far behind the rising cost of living. At M.I.T. our average monthly academic staff salary rate has gone up about 30 per cent since 1939. By means of the annual salary plan instituted at the end of the war, and involving summer-term duties which had not been included before, the total assured take-home pay of our faculty has increased about 45 per cent. It should be pointed out, however, that many of our staff on the old nine-month plan earned extra compensation during the summer, both at the Institute and outside, opportunity for which has shrunk or vanished under the twelve-month plan. Thus, while the annual plan benefited the faculty as a whole, it may not in individual cases have increased the total compensation, and the actual average compensation from all sources has not increased by as much as 45 per cent. Also in this period the tuition has been raised by 16⅔ per cent.

The President's Report concluded with a summary of changes in personnel, nearly all of which have already been recorded in recent issues of The Review. All Alumni may take genuine satisfaction in witnessing the gradual development of plans for a new era at Technology, which are so ably envisioned and outlined in the President's Report of Dr. Compton.

(*Continued on page 118*)



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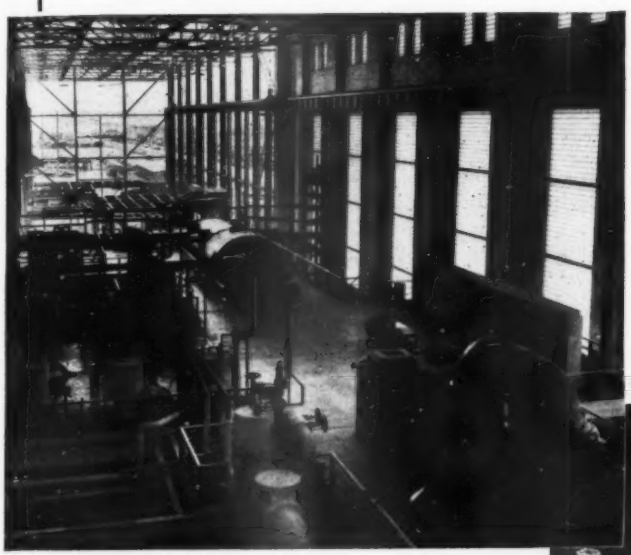
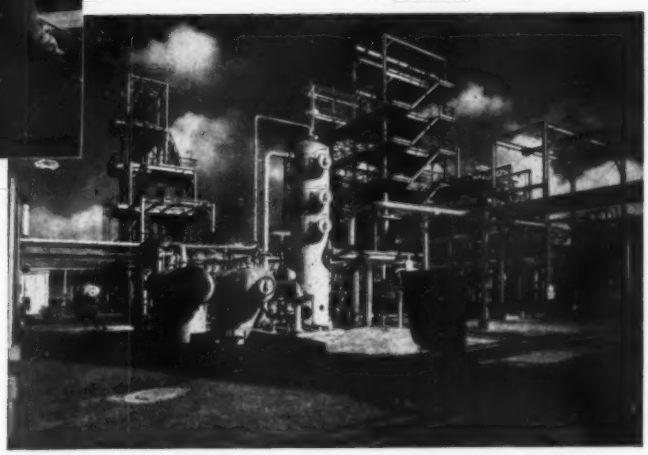


Interior view of First Section of new Redondo Steam Station of Southern California Edison Company, now under construction at Redondo Beach, California.



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(*Continued from page 116*)

From the Treasurer

IN presenting his annual report on the financial status of the Institute at the Corporation meeting on October 4, Horace S. Ford, M.I.T. Treasurer, announced that the total volume of transactions for the fiscal year ending June 30, 1948, was $21,000,000 or $4,000,000 in excess of the 1947 figure. This increase is accounted for largely by additional revenues from research contracts, but the year's volume is considerably less than the all-time peak reached in the war period of 1945. Research contract revenues were $13,301,000 in 1948 compared to $9,825,000 in 1947.

With the largest enrollment in the Institute's history, income from students, including loan and scholarship awards, was $4,068,000 or $638,000 more than a year ago. In the 1947 fiscal year, two thirds of the income from tuition fees came from the Veterans Administration Office, but this figure has dropped to one half of the tuition receipts for the current year; it will drop still further in the coming year.

Academic expenses of $5,039,000 were $351,000 above the figure for 1947, with general administrative expenses $271,000 above the 1947 amount. Plant operation, including repairs and alterations, was $1,335,000, a decrease of $130,000 from the previous year. Total income exceeded expenses by $204,456 and the cumulative deficit for the Institute's 84 years of operation now stands at $21,119.

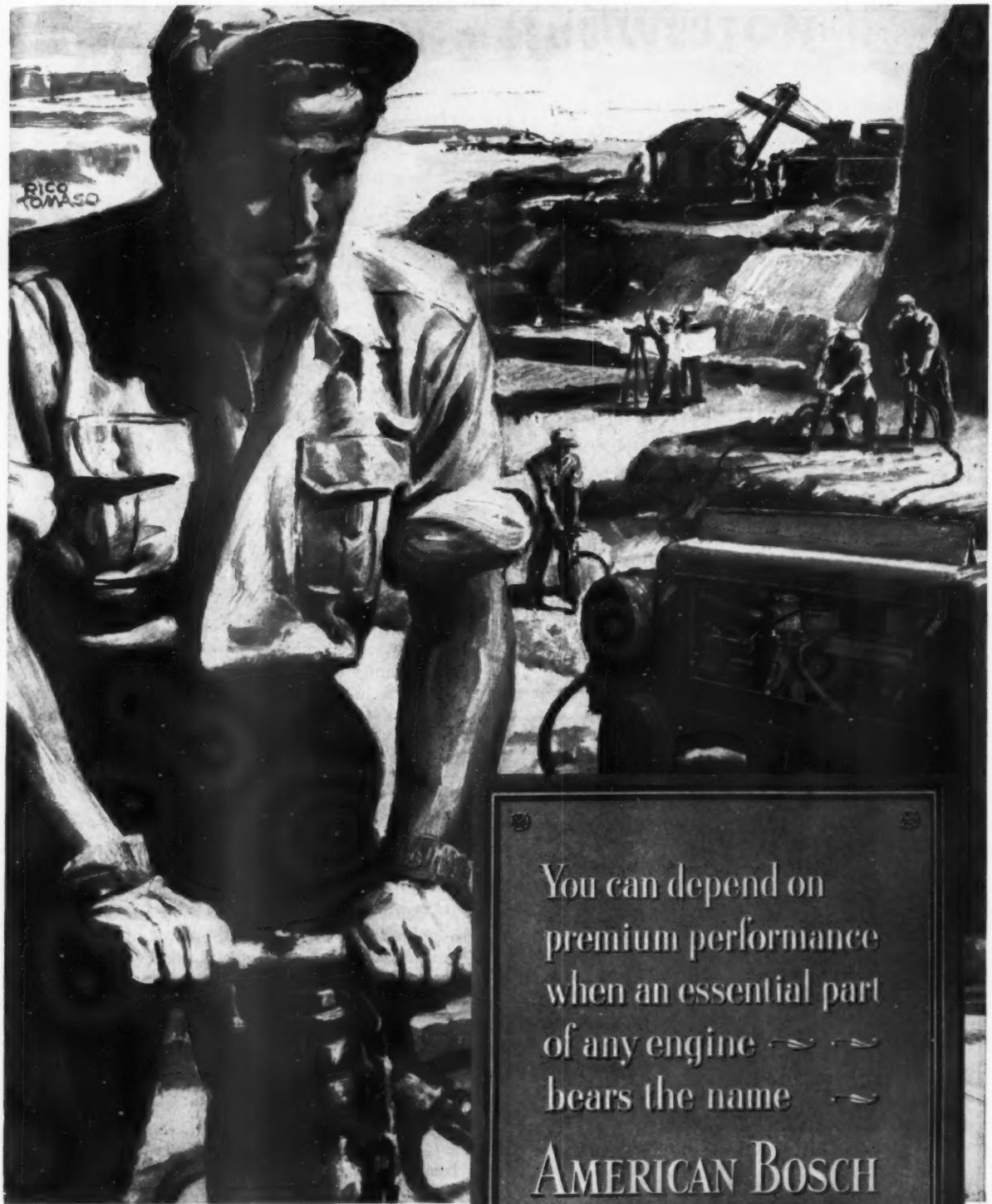
An interesting flow chart in the Treasurer's Report shows the manner in which income and expenses are distributed:

INCOME	PER CENT
Tuition, civilian students	10
Tuition, Veterans Administration	10
Income from investment	6
Gifts and other funds and receipts	8
Research contracts (reimbursement for administrative and plant expenses)	5
Research contracts (reimbursement for direct expenses)	55
Dormitories, dining services, and so on	6
EXPENSES	
Academic expenses	24
General and special administration	7
Plant operation	6
Medical and other expenses	2
Research contracts, direct expenses	55
Dormitories, dining facilities, and so on	6

The emphasis which the Institute has placed on extracurricular activities is reflected in increased operating costs in certain student activities. These are summarized from the Treasurer's Report as follows:

	ANNUAL EXPENDITURE			
ITEM	AVERAGE FOR 1941-1945	1946	1947	1948
Library operation	80,000	93,000	166,000	175,000
Medical Department	65,000	80,000	138,000	153,000
Undergraduate athletics, cultural, and recreation	100,000	112,000	170,000	207,000

(*Concluded on page 120*)



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THE INSTITUTE GAZETTE

(*Concluded from page 118*)

Humanities Series

Several important musical events and lectures will come to the Institute this year as a part of the program of the new M.I.T. Humanities Series. By supplementing other lectures and programs already organized at M.I.T., the Humanities Series aims to broaden the experiences and horizons of the technical students at the Institute.

The series was inaugurated on October 28 in an all-Beethoven program by the London String Quartet, arranged through the co-operation of Mrs. Elizabeth Sprague Coolidge. Interested members of the Faculty and student body filled Huntington Hall. By means of a public address installation, the concert was also made available to an overflow audience in the lecture hall of the Eastman Laboratories.

Lecturers now scheduled to appear in the Humanities Series at M.I.T. during the coming months are: C. Crane Brinton, Professor of Ancient and Modern History at Harvard University; F. S. C. Northrop, Professor of Philosophy in the Yale University Law School; and Margaret Mead, anthropologist with the American Museum of Natural History, New York, Dr. Killian announced in opening the series under the administration of Professor John E. Burchard, '23, Dean of Humanities.

Events in the M.I.T. Humanities Series will be representative of all five areas of studies involved in the Division of Humanities at the Institute. They will thus cover literature, history, music, economics, and business.

EARLY CHINESE ROCKETS

(*Continued from page 102*)

against wind and rain, and were supplied with straps by which they could be held in front of the soldier in position for use. Each basket carried about 20 arrows connected to a master match which passed through an aperture in the side of the basket. The arrows had steel tips smeared with poison, and carried pellets of incendiary composition which took fire after the driver charge had burned out. "These are particularly efficient for the burning of fodder, wall-towers, and ships. On meeting the enemy it is possible to anticipate the attack."

One portable launcher consisted of a small wooden box with a leather cover, arranged to fire a cluster of 100 small rocket-arrows. The shaft of each arrow was of bamboo, one and six-tenths feet long, the driver tube three-tenths of a foot long, and a piece of iron was attached behind the feather so that the center of gravity was four fingers width below the mouth of the driver tube. The arrows flew for a distance of more than 300 paces. Other sizes were used against boats and carts, but the kind described here was short and small, and intended to be carried in infantry battles

(*Concluded on page 122*)

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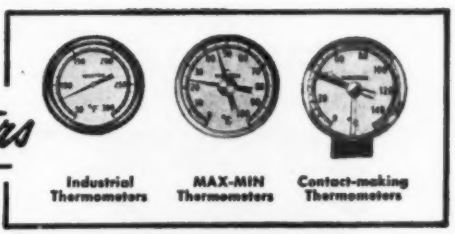

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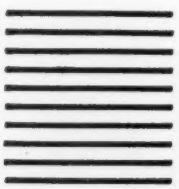

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EARLY CHINESE ROCKETS

(*Concluded from page 120*)

on land by one soldier. Other launchers contained two sets of 25 rocket-arrows, the sets arranged to be fired separately from opposite ends of the carrying case (Fig. 7).

Another portable launcher (Fig. 8) fired 30 rocket-arrows having shafts two and nine-tenths feet long and driver tubes four-tenths of a foot long. "Each box is to weigh not more than five or six pounds, so that one soldier may carry it. Wait until the enemy is within 200 paces, then fire suddenly all at once. The effect is fierce, so that one soldier is superior to thirty."

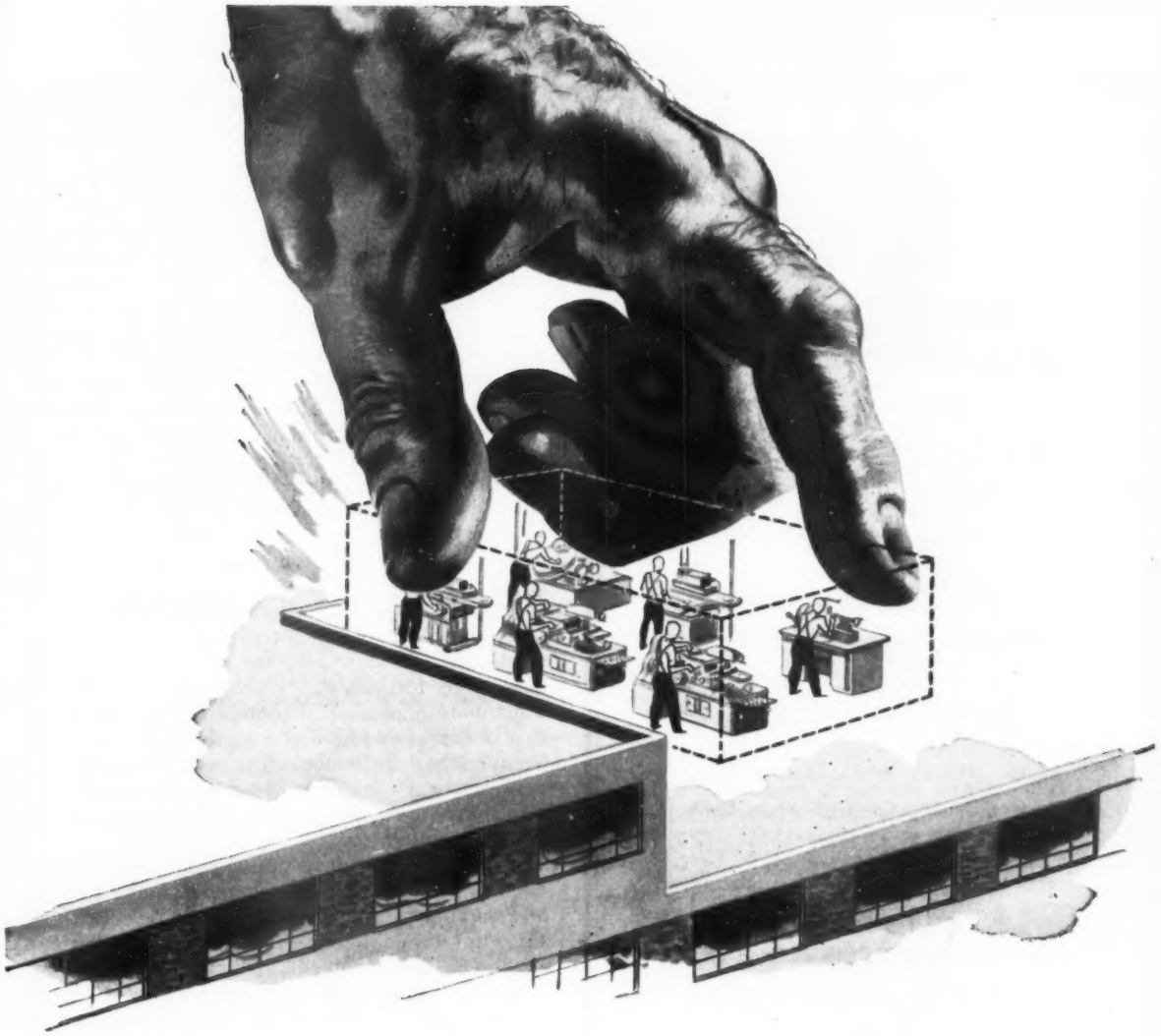
Another portable launcher (Fig. 9) fired 40 powerful rocket-arrows, sticks two and three-tenths feet long, driver tubes five-tenths of a foot long, carrying iron weights behind the feathers to bring the centers of gravity six fingers width below the mouths of the driver tubes. The arrows flew more than 400 paces. Before firing they were held in the launcher with their heads separated more widely than their tails, so that they spread out in flight and scattered transversally over a width of several hundred feet. "Whenever meeting with the enemy in the open country, merely with 10 or so boxes before the ranks, for a breadth of several thousand feet everything will be arrows."

A fixed launcher of a size to hold 100 or more rocket-arrows was made of wooden boards, and was set upon an iron axle between two supports so that it could be tilted to vary the range. "Whenever there are bandits to be suppressed, [this contrivance] being stationed on the strategic roads, aim it and fire. The arrows will go for several hundred paces. If these are made in several hundreds, it will indeed be a great help."

Before the early part of the Seventeenth Century Chinese ingenuity had already adapted rockets to a variety of special military uses, and had developed tactical techniques which are useful today with rockets carrying charges of high explosive. The Europeans of the same time had developed larger and fancier rockets for recreation and display. Biringuccio in 1540 described rockets which burst at the top of their flight sending forth six or eight other rockets or serpents,[3] and Hanzelet Lorrain (Jean Appier) in 1630 described rockets which threw out crackers (grasshoppers), stars, and serpents. The latter recommended the military use of rockets of six or seven pounds weight with grenades in their heads, which, he believed, would frighten both men and horses, and would easily break up a squadron of cavalry.[4] This is the only warlike application of rockets mentioned in his book, and represents, apparently, the most advanced thinking in Europe at that time on the tactical use of rockets in acts of warfare.

[3]*The Pirotechnia of Vannoccio Biringuccio, translated from the Italian with an introduction and notes by Cyril Stanley Smith & Martha Teach Gnudi,*" The American Institute of Mining and Metallurgical Engineers, New York, 1942, page 443.

[4]Lorrain, *La Pyrotechnie,* Pont à Mousson, 1630, pages 224–225; 234–239.



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SCIENCE IN EDUCATION

(*Continued from page 100*)

with this reasoning lies in the fact that of the 500,000,000 gallons, all of it was industrial alcohol, and none was for beverages.

The illustrations I have used are intended to suggest the value of a little knowledge of science and technology and some training in quantitative thinking as part of the perspective of a general education for nonscientists and nonengineers. I have not meant to imply that all students should elect science or engineering as careers. Indeed, the scientist and engineer need much more of the appreciation of values which a liberal arts training provides. This need has been expressed formally in the 1940 report of the American Society for Engineering Education, which calls for the development in engineering graduates of an "adequate concept of the duties of citizenship in a democratic society, an acquaintanceship with the enduring ideas and aspirations which men have evolved as guides to ethical and moral values, and with an appreciation of cultural interests lying outside the field of engineering." The four-year engineering curriculum today has a larger fraction of humanistic and cultural subjects than at any time since engineering curricula were formulated a century ago. The trend toward more nontechnical content in engineering curricular has been followed in spite of the increasing complexity of technology. The reason is simple and very practical – engineers need to know more of the humanities not merely to be better citizens, but to be better engineers.

If liberal arts graduates need more general knowledge of science and technology, certainly scientists and engineers need more breadth. Logic is a great thing but it is not to be revered as the only criterion of sound thought. Problems of human relations may sometimes be solved by logic, but the logical solutions are not always necessarily the best. Statistics are said to show that chemical engineers are the most happily married of professional people, but I suspect that, if true, this is due to wise rejection of logic in the inevitable domestic crises, rather than to the application of the scientific method to the problems of married life. Unless engineers understand the limitations of science and logic, their education may prove to be not only faulty but dangerous as well.

I do not know that it has been done, but I suspect a clever writer could make out quite a case for the benefits of war to civilization. In answer to the statement that wars never settle anything, he would point out that one war established this great country, and that a second war made it one. He would point out that the death rate due to automobile accidents in peacetime is half as great as the average death rate among United States military personnel during World War II. He would point to the wartime acceleration of medical research, which doubtless added more man-years to American lives than were lost during the war. Penicillin, a war baby, will save as many lives in a single year as this country lost in five years of war. Production and employment are at their peaks during a war. The

(*Concluded on page 126*)

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SCIENCE IN EDUCATION

(Concluded from page 124)

great wartime developments in atomic physics, which the war advanced by perhaps a generation, can reasonably be expected ultimately to mean as much to the improvement of man's material well-being in peacetime as did the industrial revolution. Properly developed and documented, such an argument would show by cold logic that we ought to promote a continuous war. If engineers or scientists, brought up on the scientific method and the sancity of logic, should be so lacking in a sense of values and so inculcated with materialistic philosophy as to be taken in by such an argument, then we should, indeed, close our schools of science and technology.

It is not sufficient to recognize that science has become more important than it was a generation ago; it is developing so rapidly that it may dominate our whole way of life. To educators and to students the implications are clear – schools of the liberal arts should provide more general education in science and its meaning to all of us; graduates in science and engineering should have that sense of values and awareness of the real place of science in men's lives without which they might use science for evil. In science today we have a giant in our midst and perhaps should remember Shakespeare's warning:

> "O, it is excellent
> To have a giant's strength; but it is tyrannous
> To use it like a giant."

ANDRÉ-MARIE AMPÈRE

(Continued from page 108)

and, at times, poetry. Toward the end of his life Ampère was working on an "Essay on the Philosophy of the Sciences" which, unfortunately, was never completed. This was a prodigious undertaking, and aimed to classify all sciences based on principles which, today, would be considered somewhat fanciful.

But of the many contributions of his versatile mind, Ampère will always be best known for his great cardinal formulation of electrodynamics – a branch of electricity which Ampère established almost alone in a few weeks of brilliant experimental research and mathematical analysis. This work is of sufficient importance to merit treatment in some detail, but Ampère's contribution may be better appreciated, however, after a survey of the state of electrical knowledge which led to his establishment of electrodynamics.

Electrical Science up to 1820

At the beginning of the Eighteenth Century, knowledge of electricity was meager, fragmentary, and unco-ordinated. There were no means for producing an electric current until 1800 and all studies of the new science were confined to an examination of electricity at rest – to which the name "electrostatics" has been given.

About 1720, Stephen Gray in England found that electric charges could be transmitted for distances of at least several hundred feet, and a dozen years later, in France, Charles François de Cisternay Du

(Continued on page 128)

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ANDRÉ-MARIE AMPÈRE

(*Continued from page 126*)

Fay recognized the difference between electrical conductors and insulators. Du Fay also discovered there were two kinds of electricity, and found that all materials could be electrified, under appropriate conditions, and so put a stop to the avid search then going on for new substances for electrification. Du Fay also established the first law of electrostatics; bodies charged with the same kind of electricity repelled one another, whereas bodies charged with different kinds of electricity exhibited a force of attraction. In experiments conducted at Philadelphia, about 1745, our own versatile Benjamin Franklin not only proved the electrical nature of lightning, as every schoolboy now knows, but developed the single-fluid theory of electricity which is the forerunner of our present notions.

The discovery of the Leyden jar, in 1745, independently by van Musschenbroek of Leyden and von Kleist of Pomerania, was an important step in electrical progress, since for the first time it made possible the collection and storing of electric charges. The peculiarly shocking properties of the Leyden jar discharges attracted much attention at the time and were even exploited by circus performers. In the seventh and eighth decades of the Eighteenth Century the first quantitive knowledge of electrostatics was developed. At the suggestion of Franklin, Priestley, in 1766, and Cavendish, in 1771, made the first determination of the law of forces of electrical charges in England. But it remained for the Frenchman, Coulomb, to develop the torsion balance with which he determined and enunciated the inverse square law of force for electric charges. This first quantitative law of electricity was stated by Coulomb in 1785, when Ampère was 10 years of age.

While England, France, and America were thus engaged in a study of electricity at rest, developments going on in Italy were to open up a new field of current electricity or electricity in motion. In 1789, Luigi Galvani, physician and anatomist in Bologna, dissected several frogs to study their nerve systems, and hung them from an iron balcony by means of small copper hooks. He observed that each time the wind blew strong enough for the frog legs to come in contact with the iron balcony, a twitching took place. Galvani carried out experiments which led him to conclude that the twitching was due to electrical causes which he incorrectly ascribed to animal electricity.

Galvani's work was studied by a contemporary compatriot, Alessandro Volta, professor at the University of Pavia. Volta concluded that the twitching was the result of action of the dissimilar metals, iron and copper, in the presence of moisture which produced an electric current. He found that acidulated water was even better than moisture, and challenged Galvani's conclusions. In a letter to the president of the Royal Society of London, Volta described his voltaic pile, the forerunner of the electric battery. This was in 1800, the year which marks the beginning of the use of current electricity by man.

(*Continued on page 130*)

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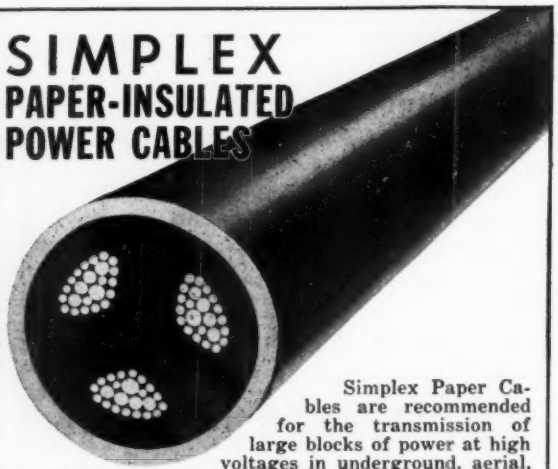

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ANDRÉ-MARIE AMPÈRE

(*Continued from page 128*)

With a means for producing an electric current, research in electricity was greatly stimulated. Davy used the voltaic pile to decompose water and there was controversy as to whether the current produced by the voltaic pile was the same as that produced by static electricity.

The relation between electricity and magnetism was long suspected, but it remained for Oersted, professor of physics at the University of Copenhagen, to establish this connection in the winter of 1819–1820. Placing a current-carrying conductor at right angles to the magnetic needle of a compass, Oersted observed the deflection of the needle as a result of the current flow. He reversed the direction of the current and the needle was deflected in the opposite direction. This was the first time any such effect between an electric current and a magnet was observed. Oersted described his experiments in a pamphlet published in Latin on July 21, 1820; a French translation by Arago appeared in the following August. Oersted's experiments pointed the way to what was to become an important development in electricity, but the Danish physicist was content merely to describe rather than to analyze his experiments. His experiments were the fulminating cap which set off Ampère's penetrating analytical ability.

In Switzerland, Arago had witnessed de La Rive perform Oersted's experiment. When he returned from that country, Arago repeated Oersted's experiment before the French Academy on September 11, 1820. Ampère was present. Exactly one week later, on September 18, 1820, Ampère read the first of four significant papers in which the work of Oersted and Arago was amplified and new concepts of the forces between current-carrying conductors were enunciated. With the aid of ingenious experiments he verified, predicted, and generalized the forces acting between current-carrying conductors. In an article in the *Annales de Chimie et de Physique*, in 1822, Ampère established the now well-known fundamental laws of electrodynamics which may be summarized as follows:

1. When the direction of the current flow is reversed, the magnetic effect of the current is likewise reversed.

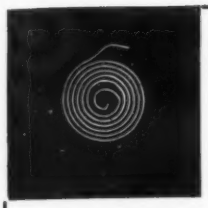
2. The effect of a current flowing in a circuit composed of a twisted pair of conductors is the same as if the circuit were smoothed out.

3. The force exerted by the magnetic effect of a closed circuit, acting on an element of another circuit, is at right angles to the latter.

4. If the magnitudes of the currents flowing in two circuits remain unchanged, the force between the two circuits is unaffected when all linear dimensions are changed in the same proportion.

Ampère also showed that the magnetic effect produced by an electric current is equivalent to a distribution of magnetism on a surface of which the circuit is the boundary. His development of electrodynamics was presented in final form before the Institut in

(*Continued on page 132*)



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ANDRÉ-MARIE AMPÈRE

(*Continued from page 130*)

1826 in a paper entitled *Théorie Mathématique des Phénomenes Electrodynamiques Uniquement Déduite de l'Expérience.* Thus, in the brief period of six years, an entirely new field of electricity was opened up by Ampère, while the major portion of his important contributions were made within a month after he learned of Oersted's experiments from the demonstration made by Arago.

Ampère's Name Immortalized

Almost a half of a century slipped by after Ampère's death (45 years to be exact) and nothing was done to memorialize the name of him who founded the science of electrodynamics. But there were men who had not forgotten. In 1881, in the city of Paris, there where Ampère had done such brilliant work, a meeting of the International Congress of Electricians was held. Having in mind the remark of the brilliant Scotch physicist, Clerk Maxwell, who said that Ampère was "the Newton of Electricity," Helmholtz, the famous German physicist, proposed that the practical unit of electric current be named *Ampère.* Others suggested that the unit be called the *Weber,* after a German physicist who was still living. But Helmholtz, aided by the efforts of Mascart, the French physicist and meteorologist, won out. What a delightful and gracious *beau geste* of the German Helmholtz.

But Ampère's name is not memorialized alone in the practical unit of electric current. Streets, squares, avenues, public schools, and public buildings were named after him at home and abroad. Some readers of these pages may have taken a train ride from Hoboken to East Orange, N.J., during which they would have found themselves passing a station bearing the name *Ampere.* The town has many small establishments, including a theater, a bank, and a street, all called by the name of Ampere. Ampere, in the state of New Jersey, is a town within a city – the city being East Orange. How has this come about? It was in 1893, and through the efforts of Francis B. Crocker and Schuyler Skaats Wheeler, that the station in East Orange, formerly known as Crescent, was named Ampere. A plaque bearing the bas-relief of Ampère was unveiled in October, 1908, by the French ambassador to the United States, Jules Jusserand, in the presence of many distinguished men of science.

(*Concluded on page 134*)

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ANDRÉ-MARIE AMPÈRE

(Concluded from page 132)

On December 4, 1920, on the one hundredth anniversary of Ampère's discoveries, a bronze wreath and tablet were added. Prince de Béarn, of the French Embassy, officiated, and speeches were made by Michael I. Pupin and many others.

At the time of the centenary of his death, Georges Kempflin wrote a short account of Ampère in the French newspaper *Paris Soir,* including his intimate life. He said:

It was at Poleymieux where he met Julie Carron, the great love of his twenties. First and delicious romance, the ups and downs of which the lover wrote in his diary with touching simplicity . . . "We went into the lane where I climbed the big cherry tree . . . I ate the cherries which were in her lap . . . we went into the big garden where she accepted a lily from my hand . . . lastly we went to see the brook." Simple words these but how touching – they reach right into the heart.

The hours spent at Poleymieux were the happiest hours of the life of the great man. They were short. Five years of happiness[8] without a cloud and the book was closed. Julie died leaving this fine and great man of science, and promises of fame, in the deepest affliction.

The brook is always there; in the springtime there are always lilies in the garden and cherries in the cherry tree. The souvenir of her who lit the great fire floats anew in these places as of yore. This is due to the munificence of two Americans, Hernand and Sosthènes Behn, that the old family house of Ampère has become the property of his spiritual descendants, The Society of the Friends of Ampere who have made it into a sanctuary of the souvenirs and a museum of Ampère's discoveries.

For 67 years, since 1881, the world has known the word *ampere.* We hope that, at least those who have read this article, will now also know the man – the Frenchman a German immortalized – *André-Marie Ampère.*

[8] This is incorrect. It was only four years. See page 107.

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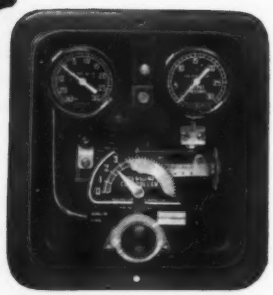

Interior View of Model No. 2500

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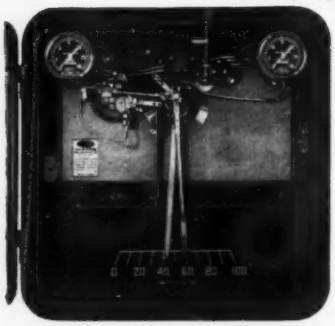

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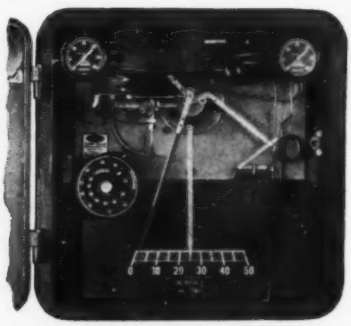

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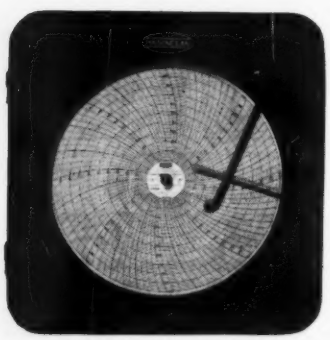

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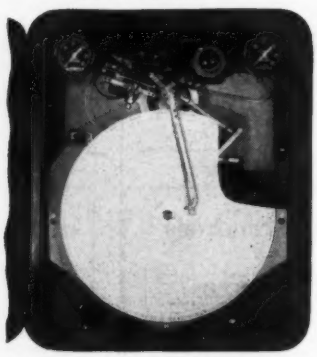
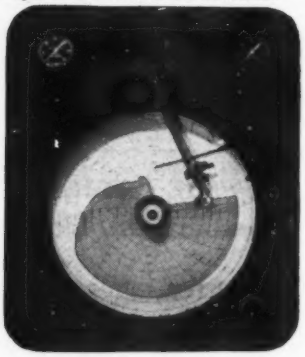


Model No. 2110 Recording Proportional Pressure Controller.



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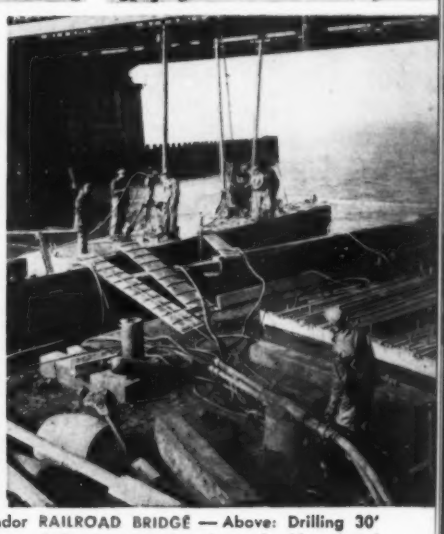

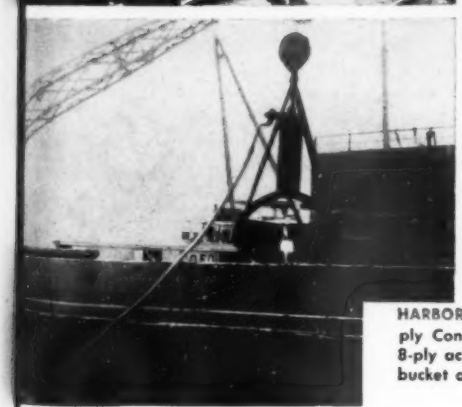

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